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Conclusion of Soviet-French Mission to 'MIR'

'MIR' Crew Holds Press Conference

18660076a Moscow PRAVDA in Russian 19 Dec 88 p 1

[TASS Report]

[Text] Flight Control Center, 18 December. The joint flight of Vladimir Titov, Musa Manarov, Valeriy Polyakov, Aleksandr Volkov, Sergey Krikalev and Jean-Loup Chretien has continued for three weeks.

Today is a day of rest for the international crew. In the course of a press conference held during two periods of television communication, the cosmonauts responded to numerous questions from Soviet and foreign journalists.

The programs of the longest manned mission in the history of cosmonautics and of the Soviet-French expedition are nearing completion. Tomorrow the cosmonauts will perform the final portion of scientific research and experiments and begin preparing the spaceship "Soyuz TM-6" for descent from orbit.

The flight of the manned complex "Mir" is proceeding in accordance with the designated schedule. All of the cosmonauts are feeling well.

Earthquake-Damaged Areas of Armenia Photographed From 'MIR'

18660076b Moscow PRAVDA in Russian 20 Dec 88 p 2

[TASS Report]

[Text] Flight Control Center, 19 December. The flight of the Soviet-French crew on board the orbiting complex "Mir" is nearing completion.

Today the cosmonauts performed the final portion of experiments in line with the program of joint research. Using a stationary camera, Aleksandr Volkov and Sergey Krikalev carried out a series of photography of individual areas of Armenian territory which were damaged by the earthquake.

Preparations have begun for the descent from orbit of the transport spaceship "Soyuz TM-6," in which Vladimir Titov, Musa Manarov and Jean-Loup Chretien will return to Earth. The crew has checked the functioning of onboard systems of this ship. In the course of the day, they will be engaged in stowing materials from completed research in the spaceship's reentry vehicle.

According to evaluations made by physician Valeriy Polyakov, the condition of all of the cosmonauts' health is good, and they are feeling well.

The flight of the manned complex "Mir" is proceeding normally.

Final Preparations For Return to Earth of Titov, Manarov, and Chretien

18660076c Moscow PRAVDA in Russian 21 Dec 88 p 1

[TASS Report]

[Text] Flight Control Center, 20 December. The joint flight of six cosmonauts on board the orbiting complex "Mir" is ending. The research program of Soviet-French studies has been carried out in its entirety. The return of cosmonauts Vladimir Titov, Musa Manarov and Jean-Loup Chretien to Earth is planned for 21 December at 0949 hours Moscow time.

Today the crew is stowing motion picture and photographic film in cassettes, tape recordings, spectrograms, biological specimens in containers, and flight documents in the reentry vehicle of the spaceship "Soyuz TM-6."

In line with the plan of preparations for the descent form orbit, the cosmonauts are performing final conditioning exercises under the supervision of physician Valeriy Polyakov, using the pneumatic vacuum suit "Chibis" and a multipurpose physical-culture training set.

In the course of the day, Aleksandr Volkov and Sergey Krikalev are also to check onboard systems of the spaceship "Soyuz TM-7" prior to redocking of the ship from the "Kvant" module to the "Mir" station's adapter module, which is planned for 22 December.

The cosmonauts are feeling well. The work in orbit is proceeding in accordance with the designated schedule.

Cosmonauts Return to Earth in 'Soyuz TM-6'

18660076d Moscow IZVESTIYA in Russian 22 Dec 88 p 1

[TASS Report]

[Excerpt] Soviet cosmonauts Vladimir Titov and Musa Manarov and cosmonaut-researcher Jean-Loup Chretien, a citizen of the French Republic, returned to Earth on 21 December at 1257 hours Moscow time, after successfully completing a program of research and experiments on board the manned complex "Mir." The reentry vehicle of the spaceship "Soyuz TM-6" made a landing 180 kilometers southeast of the city of Dzhezkazgan. The cosmonauts were feeling well after the landing. Aleksandr Volkov, Sergey Krikalev and Valeriy Polyakov are continuing work in orbit.

An orbital mission lasting one year was carried out by Soviet cosmonauts Vladimir Titov and Musa Manarov, for the first time in history.

An extensive program of astrophysical, geophysical and medical studies and technological and biotechnology experiments was carried out on board the "Mir" complex during that time.

A substantial place was reserved for work on research of Earth natural resources and study of the environment. Visual observations and photographing of land surface and waters of the world's oceans were conducted regularly. More than 12,000 photographs of Earth's surface were obtained.

The five Soviet cosmonauts and the French cosmonaut conducted joint research on board the orbiting complex over a period of 23 days, beginning 28 November 1988. A large portion of the working time during the international crew's mission was reserved for medical experiments. Cardiological, psychophysiological and radiobiological studies were conducted and studies were made of metabolic processes in the human organism, using new methods and improved equipment.

Results obtained in the course of the mission are of great scientific value and will be used in different branches of science and our country's economy. They will serve the cause of progress and benefit all of Earth's people.

Computer Problem on 'Soyuz TM-6' Delays Landing

18660076e Moscow IZVESTIYA in Russian 22 Dec 88 p 1

[Article by B. Konovalov, special correspondent at the Flight Control Center]

[Excerpt] Titov and Manarov began to prepare in advance for their long-awaited meeting with Earth. The strategy of medical personnel was not to let the cosmonauts get too accustomed to weightlessness. They therefore used the onboard running track for one hour twice a day, so that there would be constant physical exertion. After making his egress into open space, Chretien also began to engage in physical exercises twice a day.

A. Grigoryev, director of the Institute of Medical-Biological Problems, told journalists: "We conducted about 40 detailed medical examinations of Titov and Manarov in the course of a year. A favorable prognosis for landing can be made on the basis of the sum total of all data at our disposal. We have no misgivings about the state of the cosmonauts' health."

But this confidence of medical personnel alone was not enough. Equipment had to perform reliably, too. And it had an unpleasant surprise in store.

"Soyuz TM-6" undocked smoothly from the orbiting complex and hovered not far from the station, as though it were bidding farewell to its orbiting home. Independent navigation then began. While performing test checks, however, the crew discovered trouble in an onboard computer. The Flight Control Center decided to call a 'time-out' in order to investigate the situation, and landing was postponed for three hours.

A quick analysis indicated that the onboard computer evidently was operating in accordance with two programs, and this had caused the computer's on-line storage to overflow. The Flight Control Center took measures to eliminate this trouble and drafted a strategy for operations in the event that the computer had to be switched off. It was recommended that the cosmonauts use a reserve analog control circuit. Decisions were made as to the cases in which a transfer would be made to manual control, and versions were even discussed in which landing would be postponed until the following day.

"Nevertheless, we think that everything will end normally today," said flight director V. Ryumin.

General-Lieutenant V. Shatalov, director of cosmonaut training, contacted the spaceship's crew: "Your landing will now be made not near Arkalyk but in the vicinity of Dzhezkazgan. Our search group has already flown there. Conditions are good. Visibility is 3-4 kilometers. The temperature is minus 16 degrees."

Everyone on Earth waited with bated breath until the crew put the landing program into operation for the second time.

Hurrah! Everything proceeded normally. Orientation of the spaceship was completely accomplished before the descent.

The ship's braking engine was fired over the South Atlantic. The cosmonauts reported, via the seagoing ship "Kosmonavt Vladislav Volkov" and a communications satellite, that the engine had operated for the specified period of time.

Incorrect Computer Program on 'Soyuz TM-6' Cause of Delay

18660076f Moscow TRUD in Russian 22 Dec 88 p 2

[Article by V. Golovachev, special correspondent at the Flight Control Center]

[Excerpt] In a matter of seconds, an irregular situation which unexpectedly developed noticeably complicated the final and most critical stage of the space odyssey—the return to Earth of Vladimir Titov, Musa Manarov and Jean-Loup Chretien.

At 0630 hours the spaceship "Soyuz TM-6" undocked from the orbiting complex and moved slowly away from it.

The stage of firing the ship's engine was not reached on this orbit, however. The onboard computer suddenly issued an emergency signal: "Overflow." The computer immediately switched off the spaceship's descent program in this situation, of course.

It was as yet difficult to analyze precisely what was happening, but deputy flight director V. Blagov reported to journalists that the general picture had been determined on the basis of preliminary data. Specialists had been very much concerned about the irregular situation which arose several months ago during the Soviet-Afghan crew's return to Earth. As has been reported, landing had to be postponed for 24 hours then. Temperamental operation of a sensing device which is used in orienting the spaceship was one of the reasons for the difficulties that occurred.

This time, specialists decided to develop a means of protecting the device against solar interference, in order to make automation more reliable. This protection consisted in special programming of the ship's onboard computer.

It appeared that tests had been completed on the ground and suitable calculations made. As was found out yesterday, however, one of the computer's programs was written 'incorrectly,' as specialists put it. Interaction between a new program and ones which were already in the computer had not been taken fully into account. This had not been discovered on Earth, for some reason or other.

One solution was simple: shut down the 'interference protection' and operate without it. No one could fully guarantee that there would be no new surprises, of course. Many versions were therefore prepared for use in the event that other systems failed and emergency situations arose.

The transport spaceship "Soyuz TM" can be in independent flight for four days: two from the moment of launching until the ship docks with the space station, and two during the ship's return to Earth. This meant that Thursday would be the last day, on which the ship would have to be landed without fail.

Following the Soviet-Afghan crew's irregular landing, changes were made in the return program. Now the spaceship's living compartment does not separate until the ship's braking engine finishes operating. If Titov, Manarov and Chretien had to postpone the landing for a day, they would have quite decent living conditions, unlike the Soviet-Afghan crew.

Carrying out recommendations received from the ground, the cosmonauts removed the 'incorrect' program from the computer before leaving the zone of radio visibility. They then switched on onboard automation which oriented the ship perfectly normally.

A. Volkov, S. Krikalev and V. Polyakov will continue their space mission until 29 April when the next shift of cosmonauts will be on board the station.

FTD/SNAP

Cosmonaut Titov Optimistic on Prospects for Two-Year Space Missions

18660077 Moscow KOMSOMOLSKAYA PRAVDA in Russian 22 Dec 88 p 4

[Article by S. Leskov, special correspondent at the Flight Control Center]

[Excerpt] Cosmonauts V. Titov, M. Manarov and Jean-Loup Chretien have returned to Earth.

There has been no substantial change in the working fitness and good spirits of Titov and Manarov. Objective indicators recorded by onboard medical equipment are within the limits of similar indices of Yuriy Romanenko, the holder of the previous record for time in orbit. What the cosmonauts themselves had to say on this subject is interesting. Titov guaranteed, with unconcealed optimism, that cosmonauts would now be able to work in orbit even for two years.

After landing, the crew headed not as usual for Baykonur but for Star City in suburban Moscow. This confirms that the cosmonauts are in good condition, so that medical personnel consider its unnecessary to take precautions. Only after Titov and Manarov undergo an extremely careful medical examination will it be possible to talk about further increasing the duration of space expeditions.

FTD/SNAP

'Soyuz TM-7' Shifts Docking Position on 'Mir' Complex

18660094 Moscow IZVESTIYA in Russian 23 Dec 88 p 1

[TASS report]

[Text] Flight Control Center, 22 December. The space mission of Aleksandr Volkov, Sergey Krikalev and Valeriy Polyakov is continuing on board the orbiting complex "Mir".

In line with the mission's program, the spaceship "Soyuz TM-7" was redocked today from the "Kvant" module to the station's adapter module. The rearranging of the manned complex was carried out for the purpose of ensuring further operations for supplying it with fuel, equipment and other cargo items, using unmanned "Progress" spaceships.

Before the undocking, the cosmonauts went into the transport spaceship and closed the hatches. The "Soyuz TM-7" spaceship separated from the orbiting complex at 0945 hours, Moscow time.

On commands from onboard automation, the station made a 180-degree turn and was oriented in space. Using the system of manual control, the cosmonauts executed an approach of the spaceship and docked it with the adapter module at 0959 hours.

The condition of the cosmonauts' health is good, and they are feeling well.

The flight is proceeding normally.

'Progress-39' Cargo Spacecraft Launched

18660095 Moscow PRAVDA in Russian 26 Dec 88 p 3

[TASS Report]

[Text] In line with the program for further operation of the scientific research complex "Mir", an unmanned cargo spaceship, "Progress-39", was launched from the Soviet Union on 25 December, 1988, at 0712 hours Moscow time.

The purpose of the launching of the spaceship is to deliver materials which become depleted and various cargo items to the manned complex "Mir".

The "Progress-39" spaceship was placed into an orbit with the parameters: maximum distance from Earth's surface—255 kilometers; minimum distance from Earth's surface—193 kilometers; period of revolution—88.7 minutes; inclination—51.6 degrees.

According to telemetry information, the onboard systems of the unmanned cargo spaceship are functioning normally.

'Progress-39' Docks With 'Mir' Complex

18660096 Moscow PRAVDA in Russian 28 Dec 88 p 1

[TASS Report]

[Text] The cargo spaceship "Progress-39" docked with the manned complex "Mir" on 27 December, 1988, 0835 hours Moscow time.

The mutual search, rendezvousing, approach and docking were carried out with the aid of onboard automation. These processes were monitored by the Flight Control Center interacting with the ground command-and-measurement complex, and also by cosmonauts Volkov, Krikalev and Polyakov.

The "Progress-39" spaceship docked with the complex at the end where the "Kvant" module is located. Fuel for the station's combined engine unit, foodstuffs, water, equipment, apparatus and also mail were delivered into orbit.

According to telemetry information and the crew's reports, the onboard systems of the manned complex "Mir" are functioning normally.

Aleksandr Volkov, Sergey Krikalev and Valeriy Polyakov are feeling well.

Cosmonauts Unload 'Progress-39,' Conduct Medical Exams

18660097 Moscow PRAVDA in Russian 31 Dec 88 p 1

[TASS Report]

[Text] Flight Control Center, 30 December. The last work week of the year is in progress on board the scientific research complex "Mir."

Aleksandr Volkov and Sergey Krikalev are engaged in unloading the unmanned spaceship "Progress-39" today. More than 2 tons of various cargo items which are needed for the further work of cosmonauts on board the station were delivered into orbit by this ship. Monitoring checks of individual instruments and apparatus are planned.

In line with the medical monitoring schedule, Valeriy Polyakov has conducted the latest examination of the condition of the circulatory system during his performance of physical exercises with measured amounts of exertion, using the stationary bicycle. The commander and flight engineer previously underwent a thorough examination of the cardiovascular system at rest. Various physiological parameters were recorded with the multifunctional clinical apparatus "Gamma" in the course of this examination.

The cosmonauts are feeling well, and they are in the New Year spirit.

On 31 December the crew of the orbiting complex will be contacted by Vladimir Titov and Musa Manarov, who returned to Earth several days ago following a space mission which lasted a year, and by French cosmonaut Jean-Loup Chretien, who worked on board the station for three weeks. Titov, Manarov and Chretien are now at Star City, where they are undergoing a postflight medical examination and a course of rehabilitative therapy.

Astrophysical Studies on 'Mir,' Report on Previous Crew's Condition

18660098 Moscow PRAVDA in Russian 4 Jan 89 p 2

[TASS Report]

[Text] Flight Control Center, 3 January. The flight of the permanent orbiting complex "Mir" is continuing. Aleksandr Volkov, Sergey Krikalev and Valeriy Polyakov are now working on board this complex.

The crew has been engaged chiefly in astrophysical studies during the first days of this week.

After calibrating and adjusting the "Rozhen" apparatus which was developed by Bulgarian specialists, the cosmonauts are performing a series of experiments called

"Polyarizatsiya" (polarization) today. The purpose of these experiments is to perfect methods of studying star formations. The latest series of measurements of flows of charged elementary particles with high energies in near-Earth space is being conducted with the aid of the magnetic spectrometer "Mariya."

Several more periods of observation of the supernova in the Large Magellanic cloud are planned within the framework of the international program "Rentgen".

Vladimir Titov, Musa Manarov and Jean-Loup Chretien, who returned to Earth two weeks ago, are undergoing a course of rehabilitative therapy at Star City. According to physicians' evaluations, the process of the Soviet cosmonauts' readaptation to terrestrial conditions following a year-long stay in zero gravity is proceeding normally. The period of rehabilitation for the French cosmonaut, who carried out a mission lasting 25 days, has practically been completed.

Crew Performs Astronomical Observations

18660099 Riga SOVETSKAYA LATVIYA in Russian 8 Jan 89 p 1

[TASS Report]

[Text] Flight Control Center, 6 January. The latest week of Aleksandr Volkov's, Sergey Krikalev's and Valeriy Polyakov's space mission on board the orbiting complex "Mir" is ending.

During the days just past, a substantial place was reserved for extra-atmospheric astronomy research in the crew's program of work.

Several series of experiments employing the "Glazar" telescope were performed. Sources of ultraviolet radiation in the constellations Auriga and Cassiopeia were photographed on 4 and 5 January, and photographing of individual areas of the constellation Carina is planned for today.

In line with the international program "Rentgen", studies of the supernova in the Large Magellanic Cloud are continuing. The purpose of observations of this unique astrophysical object which have been conducted recently is to obtain information about the evolution of its radiation spectrum. Scientists are interested in what was formed during the explosion of the supernova: an x-ray pulsar—neutron star, or a black hole?

In the course of the day, the cosmonauts also are to perform a number of medical-biological experiments and a required set of exercises using a physical-culture conditioning set.

The flight is proceeding normally.

The condition of Aleksandr Volkov's, Sergey Krikalev's and Valeriy Polyakov's health is good, and they are feeling well.

Work With 'Glazar' Telescope, 'Rozhen' Apparatus

18660100 Moscow MOSKOVSKAYA PRAVDA in Russian 11 Jan 89 p 1

[TASS Report]

[Text] Flight Control Center, 10 January. Aleksandr Volkov and Sergey Krikalev have been working in near-Earth orbit for 45 days. The 134th day of physician-researcher Valeriy Polyakov's space mission has ended.

In line with the program of astrophysical research, the crew is continuing experiments for the study of celestial objects in the ultraviolet portion of the spectrum. The purpose of these experiments, which are being conducted with the aid of the telescope "Glazar," is to obtain data on short-wavelength radiation of galaxies. Today the cosmonauts are to carry out a series of photographing of certain sections of the constellation Orion, in particular.

After calibrating and adjusting the "Rozhen" apparatus, the crew performed a number of experiments yesterday for the purpose of further perfecting methods for the study of various astrophysical objects.

Information on sources of x-radiation continues to be received from the orbiting complex "Mir". Several periods of observation of x-ray pulsars located in the constellation Vela and the Small Magellanic Cloud were conducted on 9 January, using a telescope of the "Kvant" module.

The cosmonauts are feeling well.

The flight of the manned scientific research complex "Mir" is proceeding normally.

Astronomical Observations, Study of Ionosphere, Atmosphere

18660101 Moscow PRAVDA in Russian 14 Jan 89 p 1

[TASS Report]

[Text] Flight Control Center, 13 January. Astrophysical research occupies a substantial place in the work of the "Mir" complex's crew.

Experiments employing research apparatus of the module "Kvant" are one of the main directions of this extensive program. During the days just past, several periods of observation of an x-ray pulsar in the Small Magellanic Cloud and of the center of an active galaxy in the constellation Canes Venatici were conducted within the framework of the international project "Rentgen". A

series of photographing of certain sections of the constellation Vela was performed with the aid of the telescope "Glazar", which registers radiation in the ultraviolet portion of the spectrum.

Today the cosmonauts are conducting experiments employing the astronomical complex "Rozhen" and the spectrophotometer "Parallaks-Zagorka", which were developed by Bulgarian specialists. The purpose of these experiments is to study physical processes occurring in the ionosphere and upper layers of the atmosphere.

According to results of medical monitoring, the condition of Aleksandr Volkov's, Sergey Krikalev's and Valeriy Polyakov's health is good.

The space mission on board the manned complex "Mir" is continuing.

Cosmonauts Perform Maintenance Operations Aboard Station

18660102 Moscow PRAVDA in Russian 18 Jan 89 p 1

[TASS Report]

[Text] Flight Control Center, 17 January. The space mission of Aleksandr Volkov, Sergey Krikalev and Valeriy Polyakov is continuing.

In accordance with the flight program, time is reserved periodically for routine preventive-maintenance work by the cosmonauts on board the permanent manned complex "Mir". Today the crew will conduct an inspection of structural elements and equipment of the station and the station's interior, and they will check the functioning of individual units of the life-support system.

The latest series of measurements of flows of high-energy electrons and positrons in near-Earth space with the aid of the magnetic spectrometer "Mariya" is planned in line with the astrophysical research plan.

Equipment for recording dynamic loads on the complex's structure is to be readied for operation and a number of technical experiments are to be performed also in the course of the day.

The condition of the health of cosmonauts Volkov, Krikalev and Polyakov is good, and they are feeling well.

Cosmonaut Activities On 'Mir' Station Complex

Europeans Join Roentgen Experiments

LD2301023489 Moscow Domestic Service in Russian 0100 GMT 23 Jan 89

[Text] A new work week is starting on board the Mir research complex. Within the framework of the international Roentgen program of experiments on extra-atmospheric astronomy, there will be several series of measurements of x-ray radiation taken today with the help of telescopes of the Kvant module. Together with Soviet scientists, specialists of Great Britain, the Netherlands, the FRG, and the European Space Agency are taking part in this work.

The day's program also includes geophysical and technical experiments.

According to the crew's report, the flight is proceeding on schedule. Aleksandr Volkov, Sergey Krikalev, and Valeriy Polyakov are healthy and feel well.

Medical Experiment Conducted

LD2101224689 Moscow Television Service in Russian 1800 GMT 21 Jan 89

[From the "Vremya" newscast]

[Summary] A communications session has been held with the cosmonauts on board "Mir." This is the first to be shown this year, simply because it so happens that "Mir" has been passing over the USSR at night all this time. The cosmonauts have been testing equipment bought from Austria, which provides rapid blood analyses. Called Reflotron, it is manufactured by the firm Boehringer Mannheim of West Germany. The cosmonauts have found the equipment compact and fast. Such equipment is already being used in the USSR in a mother and child center. [video shows cosmonauts speaking about the equipment and then shows close-ups of the equipment]

Past Week's Experiments Reviewed

LD2001105289 Moscow TASS in English 1045 GMT 20 Jan 89

[Text] Moscow January 20 TASS—By TASS special correspondent reporting from Mission Control Center:

The Soviet crew of the Mir space station are concluding one more week in orbit. During the week, Aleksandr Volkov, Sergey Krikalev and Valeriy Polyakov conducted maintenance work on onboard systems, unloaded the Progress-39 cargo ship and carried out astrophysical and medical studies.

They also conducted routine observations of the nucleus of an active galaxy in the Canes Venatici constellation under the Roentgen international project.

Physician Polyakov carried out a series of experiments with the help of Pleven-87 equipment, developed by Bulgarian specialists, to determine psychophysiological reactions and operator qualities of cosmonauts.

With the help of Gamma multipurpose recording equipment, he studied the blood-circulating systems of the commander and the flight engineer.

The plan of medical studies for today includes measuring the cosmonauts' mass, checking their hearing, and studying the cardiovascular systems during physical exercises on the bicycle ergometer.

The flight is proceeding in accordance with the program.

The cosmonauts are feeling well.

'Mir' Cosmonauts Run Experiments, Adjust Flight Path

LD2401153089 Moscow TASS in English 1524 GMT 24 Jan 89

[Text] Moscow January 24 TASS—Aleksandr Volkov, Sergey Krikalev and Valeriy Polyakov are continuing work on board the orbital space station Mir (Peace).

Along with the unloading of the unmanned transport spacecraft Progress-39, the cosmonauts carried out a number of technical, medical and astrophysical experiments.

Using a holographic gauge, the crew checked the station's portholes and assessed their optical properties.

Polyakov, a physician, underwent a medical check-up to determine parameters of his own blood circulation system in space conditions.

Under a space astronomy program, the crew observed an X-ray pulsar in the Vela Constellation.

Today, the cosmonauts investigated an x-ray source, X-3, in the Centaur Constellation.

After the flight path adjustment using propulsion units of Progress-39, the parameters of the manned orbital complex are now as follows:

—maximum distance from the earth's surface—376 km,

—minimum distance—340 km,

—period of revolution—91.4 minutes,

—inclination—51.6 degrees.

The flight is proceeding normally. The cosmonauts Volkov, Krikalev and Polyakov are feeling well.

'Mir' Cosmonauts' Weekend Activities Outlined

LD2701133589 Moscow TASS in English 1326 GMT 27 Jan 89

[Text] Moscow January 27 TASS—Aleksandr Volkov and Sergey Krikalev have been working in near-Earth orbit for two months. The flight of Valeriy Polyakov, a physician, is in the 152nd day.

This week's program of the space mission included astrophysical, geophysical, and medical experiments, as well as the unloading of the Progress-39 spacecraft. In accordance with a plan of maintenance operations onboard the orbital complex, the cosmonauts replaced hydropumps and automatic devices in one of the compartments of the temperature controlling system.

Studies within the framework of the international Roentgen program are going on. Telescopes of the orbital observatory wil be trained today on a roentgen source—a double system in the Circinus Constellation.

In the daytime the cosmonauts will conduct a number of experiments on evaluating optical characteristics of the orbital station's portholes with the help of a holographic registrator. The flight commander will undergo a medical examination for the purpose of establishing a functional state of the blood circulation system in conditions of a space flight.

Saturday and Sunday will be days off for Volkov, Krikalev and Polyakov. The cosmonauts feel well.

The space mission of the Mir orbital complex is continuing.

'Mir' Crew Conducts Astrophysical, Medical Tests

LD3101125689 Moscow TASS in English 1211 GMT 31 Jan 89

[Text] Moscow January 31 TASS—By TASS correspondent from the Mission Control Center:

The flight of the orbital research complex Mir, with Aleksandr Volkov, Sergey Krikalev and Valeriy Polyakov on board, is going on.

In accordance with the program for the study of materials in space, the crew performed a series of experiments to test in practice a technology to apply metal coatings in space vacuum and zero gravity conditions by a method of electric beam evaporation and subsequent condensation. The experiments were carried out by means of 'Yantar' apparatus, the working unit of which was installed in the orbital station's air-lock chamber. Two composite alloys of silver-and-palladium and tungsten-and-aluminium were sprayed on a polymeric film.

The cosmonauts carry on astrophysical research with the use of the international orbital observatory Roentgen. Today its telescopes will be again directed towards an x-ray source believed to be a black hole in the Circinus Constellation.

A medical control plan envisages an examination of Sergey Krikalev and Valeriy Polyakov for an evaluation of the condition of the cardiovascular system in space flight conditions. Aleksandr Volkov underwent the examination at the end of last week.

During the day the cosmonauts will also perform yet another cycle of experiments by means of the magnetic spectrometer 'Mariya'. The purpose of research being carried out now is to determine a possible interconnection between the intensive fluxes of high-energy charged particles in the area of the Brazilian Magnetic Anomaly and terrestrial seismic activity.

'Mir' Crew Carries Out Astrophysical Studies

LD0302101889 Moscow TASS in English 1012 GMT 3 Feb 89

[Text] Moscow February 3 TASS—By TASS correspondent reporting from Mission Control Center:

The crew of a Mir Soviet oribiting space station carried out a series of astrophysical studies with the help of the Roentgen orbital observatory and the Mariya magnetic spectrometer, as well as geophysical and medicobiological expriments this week.

Aleksandr Volkov, Sergey Krikalev and Valeriy Polyakov also prepared for work new highly sensitive equipment for determining the value and nature of microaccelerations emerging during the flight and dynamic characteristics of the space station's design.

The cosmonauts are completing the unloading of a Progress-39 cargo ship and loading it with used equipment. Cargos brought to the station by the unmanned craft are placed in the basic and astrophysical modules.

Simultaneously, the fuel tanks of the station's power unit are refuelled and filled with oxidizer. These operations are carried out on command of onboard equipment and controlled by the crew.

Today, the cosmonauts are to conduct a series of observations of a roentgen pulsar in the Vela constellation under the Roentgen international astrophysical research program.

According to physician Polyakov and results of medical checkups, the cosmonauts are feeling well.

'Mir' Crew Conclude Work With 'Progress-39', Perform Geophysical Research

'Progress-39' Undocked

LD0702100989 Moscow TASS in English 1002 GMT 7 Feb 89

[Text] Moscow February 7 TASS—Soviet cosmonauts Aleksandr Volkov, Sergey Krikalev and Valeriy Polyakov are continuing their work aboard the space research station Mir which has been in orbit for two years.

All planned work involving the unmanned space freighter Progress-39 completed in full, the spacecraft was undocked from the station at 0946 Moscow time on Tuesday.

The planned operations had included the unloading of freight and the pumping of drinking water, fuel and oxidizing agent from the supply craft to Mir's tanks, as well as the correction of the space station's orbit by means of the Progress-39 engine.

The space freighter will be put on a descent trajectory on Tuesday evening and then reenter the dense layers of the atmosphere and cease to exist.

The three cosmonauts, in the meantime, are to do a number of technical and geophysics experiments during the day. In addition, Polyakov is to undergo an ultrasound study of his cardiovascular system.

The spacemen are continuing astrophysics reasearch under an international program codenamed Roentgen. They conducted several more observations of the x-ray source X-3 in the Centaur Constellation on February 5 and 6.

The flight of the manned station Mir is continuing.

Crew Photographs Siberia

LD0602094689 Moscow World Service in English 0800 GMT 6 Feb 89

[Text] The Soviet cosmonauts working on the orbital complex Mir have completed a series of geophysical experiments. Aleksandr Volkov, Sergey Krikalev, and Valeriy Polyakov took pictures of the hard-to-reach regions of Siberia and the Central Asian republics. Those areas were also surveyed by a satellite from the Cosmos series equipped with a unique device. Pictures taken from orbit will help look for natural resources and also for underground fresh water lakes. Specialists will likewise be able to choose the best places to build new towns and cities.

Cosmonauts 'Feeling Good'

LD0502162689 Moscow TASS in English 1533 GMT 5 Feb 89

[Text] Moscow February 5 TASS—"The cosmonauts are feeling good." Such reports keep coming from the Mir orbital complex, manned by Soviet cosmonauts Aleksandr Volkov, Sergey Krikalev and Valeriy Polyakov. This is largely due to systematic exercises, which are seen by medical specialists as a guarantee of the successful fulfillment of the flight program by the cosmonauts.

An entire "mini-stadium" is available to the cosmonauts at the Mir station, complete with the "running track", veloergometer and other apparatus. Besides, the cosmonauts seem to enjoy the special suits which help redistribute blood and create the necessary loads in certain portions of the body. Their aim and purpose is to help man to overcome the undesirable impact of zero-gravity.

Training in space, specialists believe, is the logical continuation of the crew's physical training on earth. Exercises on a variety of simulators at the sports hall of the Cosmonaut Training Center in Moscow are included in the program of pre-launch training. For example, the "Spartacus" complex simulator helps develop and exercise all groups of muscles. On earth any exercises by the crew are monitored by a doctor. Now the cosmonauts also have their own "family doctor," Valeriy Polyakov, on the orbit who sees to it that his colleagues keep fit in zero gravity.

'Progress-40' Cargo Spacecraft Launched 10 February

LD1002110789 Moscow TASS in English 1101 GMT 10 Feb 89

[Text] Moscow February 10 TASS—The Progress-40 unmanned cargo spacecraft was launched in the Soviet Union on Friday under the program of work of the Mir piloted orbiting scientific space station.

The satellite will deliver to Mir various cargoes and replenish used materials.

The satellite was put into orbit with the following parameters:

maximum distance from the earth's surface—262 kilometers,
minimum distance from the earth's surface—193 kilometres,
period of revolution—88.8 minutes,
inclination of the orbit—51.6 degrees.

According to telemetry data, the on-board systems of Progress-40 are operating normally.

'Mir' Cosmonauts To Be Replaced at End of April

LD1402094389 Moscow TASS in English 0806 GMT 14 Feb 89

[Text] Moscow February 14 TASS—By TASS correspondent Rena Kuznetsova:

"It is planned to replace the crew of the Soviet long-term orbital complex "Mir" at the end of April," it was stated by pilot-cosmonaut Aleksey Leonov, deputy chief of the Cosmonaut Training Center near Moscow. He pointed out in a TASS interview that Cosmonauts Aleksey Volkov and Sergey Krikalev, who have been working on the orbit for almost eighty days, will most probably be replaced by a new crew headed by Aleksandr Viktorenko. As to physician Valeriy Polyakov, it has still not been decided whether he should remain on the complex or return to the Earth. Therefore, it is difficult to say now whether the replacement will be complete or partial.

We intend to replace the crew, Aleksey Leonov continued, in keeping with the National Space Exploration for Peaceful Purposes Program. A tendency has emerged of late to make use of long-term orbital complexes with replaceable crews. The one-year "marathon" of Soviet Cosmonauts Vladimir Titov and Musa Manarov ended last year. Prior to that Yuriy Romanenko remained on orbit for 326 days. As believed by medics, a one-year stay in conditions of weightlessness is not the limit for a human organism. "Modern achievements of space science help the cosmonauts to surmount undesirable effects of weightlessness. Record-long flights, are not an end in itself for us, of course", the cosmonaut stressed.

Leonov believes that the program of space research would be expanded substantially in the foreseeable future. "A special supply module will be put into orbit. This will give the crew additional opportunities for extensive space research and for practical experiments in the interests of different sectors of national economy". Plans are afoot to carry out exits of crew members into open space, it was stated by Aleksey Leonov, who was the first man to venture into open space.

'Progress-40' Cargo Spacecraft Docks With 'Mir'

LD1202124189 Moscow TASS in English 1225 GMT 12 Feb 89

[Text] Moscow February 12 TASS—The Progress-40 cargo spacecraft docked with the manned orbital complex Mir at 1330, Moscow time, on February 12, 1989.

The mutual search, rendezvous, approach and docking were carried out by means of onboard automatic equipment. The processes were monitored by the Mission Control Center in cooperation with the command instrumentation complex on the ground as well as Cosmonauts Aleksandr Volkov, Sergey Krikalev and Valeriy Polyakov.

The Progress-40 spacecraft docked with the complex from the side of the Kvant module, bringing fuel for the joint propulsion plant of the station, food, water, equipment, apparatus as well as mail.

According to telemetric data and crew reports, the onboard systems of the manned complex Mir are functioning normally. Aleksandr Volkov, Sergey Krikalev and Valeriy Polyakov are feeling well.

Recent Research Experiments Aboard 'Mir' Described

LD1402114789 Moscow TASS in English 1045 GMT 14 Feb 89

[Text] Moscow February 14 TASS—Aleksandr Volkov and Sergey Krikolev have worked in orbit for two and a half months while Valeriy Polyakov has stayed in orbit for 170 days.

In recent days the crew performed a large number of extraatmospheric astronomy experiments with the use of glazar telescope.

Ultra-violet radiation sources in Auriga and Gemini Constellations were the objects of photography beginning from February 8. Individual areas of Monoceros Constellation are planned for photography today.

The astrophysical experiments programme envisages a regular cycle of research into the fluxes of high-energy elementary charged particles and their interaction with the Earth's radiation belts.

A series of diagram experiments are being carried out to determine the physical characteristics of the atmosphere near the orbital complex and to evaluate aerodynamic drag. The necessary measurements are made by means of a magnetic-discharge transducer put outside by means of a rod through the air-lock chamber.

Under the plan of operation to handle the Progres-40 automatic cargo spacecraft, the cosmonauts are to pump the delivered drinking water into the tanks of the station.

The results of medical examinations reaffirm a good state of health of Aleksandr Volkov, Sergey Krikolev and Valeriy Polyakov.

Work aboard the manned orbital complex Mir goes on.

'Mir' Crew Continues Experiments 17 February

LD1702151189 Moscow TASS in English 1130 GMT 17 Feb 89

[Text] Moscow February 17 TASS—Correspondent reports from the Mission Control Center:

The crew of the orbital complex Mir are carrying on the planned research and experiments.

Today the cosmonauts by means of the magnetic spectrometer Mariya are performing a regular series of experiments to study the interrelationship between the characteristics of fluxes of elementary charged particles of cosmic origin in the near-earth space and seismic activity on earth.

The survey of the areas of the Crimea, Krasnodar, and Stavropol territories, and the pre-Caspian depression is planned under the program for research into the earth's natural resources and environmental studies.

This work, the first cycle of which was accomplished on February 15, is being done within the scope of the Kuban-89 aerospace experiment to estimate the state of arable lands and pastures, to identify farmland areas prone to erosion and oversaturated with mineral fertilisers. The photography and spectrometry of the earth's surface from space is accompanied by simultaneous photography from airborne laboratories and survey by ground-measuring facilities.

Today the cosmonauts are to replace individual assemblies of the radio telemetric systems—the warranty period of which expires—by new ones brought by the Progress-40 cargo spacecraft.

Aleksandr Volkov, Sergey Krikalev, and Valeriy Polyakov are feeling well.

Plans For Crew Replacement, New 'Mir' Modules

LD1902001388 Moscow TASS in English 2203 GMT 18 Feb 89

[Text] Moscow February 18 TASS—A crew of cosmonauts will be launched from the earth on April 19 to the Soviet scientific orbital complex Mir to replace cosmonauts Valeriy Polyakov, Aleksandr Volkov and Sergey Krikalev. Space expeditions will last not longer than six months. Later their duration will be increased to a year and a half. A TASS correspondent was told this on Saturday by deputy supervisor of the flight Viktor Blagov. He spoke about prospects for explorations on board the Mir station in an interview he gave to TASS in connection with the third anniversary of the station's launch observed on February 20.

Six blocks—spaceships or research laboratories—can be docked to Mir station simultaneously, Blagov said. Only one block, "Kvant", meant for astrophysical observation, is now docked to the station. A technological module which specialists regard as a prototype of a plant in space, will be docked to the station before the end of this year. Pilot production of extra pure monocrystals which can find uses in various areas of technology is to be started at the module. Experiments for their growth in weightlessness have been conducted for several years now.

Another novel feature will be special platforms fastened from the outside to the Mir-Kvant complex. Scientific equipment and instruments installed on them could be directed at celestial bodies and objects on earth without changing the orientation of Mir station in space, the way it has been done so far. Besides that, the instruments in space could be operated by a specialist from earth. The productivity of research will be increased considerably.

The deputy supervisor of the flight said that eleven Soviet cosmonauts, as well as representatives of Syria, Bulgaria, Afghanistan, and France worked on board the station during its orbital flight over three years. Alongside the wealth of data in various areas of science, extremely valuable medico-biological information has accumulated.

We expect the results of medical checks of Vladimir Titov and Musa Manarov who spent 366 days in orbit" [quotation mark as received], Blagov said. "It will take about a year to observe the state of their health. If the results of the observations are encouraging, several other flights will be made, after which it will be possible to plan an international program of man's flight to Mars."

Plans for New Modules

LD2002223789 Moscow TASS in English 2121 GMT 20 Feb 89

[Text] Moscow February 21 TASS—The Soviet Union will put into space a new module carrying scientific equipment for docking with the "Mir" space station in the second half of this year, chief spacecraft designer Yuriy Semenov told Soviet television Monday.

Space officials plan an extensive spacewalk outside the module during which cosmonauts will use autonomous flying devices.

This module will shortly be followed by another, "technological" module. It will be a mini-factory for growing crystals in conditions of weightlessness.

The crystals are intended for enterprises making electronics and lasers. Space-grown crystals will make it possible to create new super-speed integrated circuits.

The "technological" module will carry a special unit for work in biotechnology. It will produce up to 100 kilograms of products a year.

The module will also carry ecological monitoring equipment being developed now, Semenov said.

The module is to start operating in orbit at the end of 1990 or the beginning of 1991.

The new modules will not only help cover the expenses on the creation of the "Mir" complex, which have so far been covered by only 25 per cent, but also bring considerable profits running into hundreds of millions of rubles.

Semenov said the "technological" module alone will bring one billion rubles in profits.

'Mir' Crew Perform Environmental Photography

LD2302104689 Moscow Domestic Service in Russian 0100 GMT 23 Feb 89

[Text] Flight Control Center reports: The crew of the "Mir" orbiting complex was occupied with medical research for the most part of the working day on 22 February. In the environmental program studies, photographing of individual regions of the earth's surface was carried out.

According to telemetric data and the report of the crew, the flight is proceeding according to schedule and the state of health of the cosmonauts is good. They feel well.

'Mir' Orbital Parameters Adjusted, Medical Checks Set

LD2402125189 Moscow TASS in English 1129 GMT 24 Feb 89

[Text] Moscow February 24 TASS—A TASS correspondent reports from the Flight Control Center:

Aleksander Volkov, Sergey Krikalev and Valeriy Polyakov are continuing their flight on board the orbital complex "Mir". Regular filming of different regions of the USSR are being carried out in keeping with the vast program for studying the earth's natural resources and exploring the environment. Filmed today will be separate areas of the Ukraine, the Central Black-Soil belt, the Volga basin and the republics of Central Asia. Information from outer space will be used to determine the state of winter crops.

Several studies have been carried out under the program of medical control. The cardiovascular systems of cosmonauts have been checked thoroughly. Planned for today are measurements of their body masses, investigation of muscles which are underloaded in conditions of weightlessness. Furthermore, the crew commander will be subjected to electrocardiological investigation under the doctor's supervision. The flight engineer will be busy preparing the equipment for forthcoming experiments.

The flight trajectory was corrected this morning by means of the "Progress-40" automatic vehicle's propelling unit. Now the orbit of the piloted "Mir" complex is: Maximum distance from the earth's surface—386 km, minimum—358 km, rotation period—91.7 min., inclination—51.6 degrees.

Refuelling of 'Mir' Joint Propulsion Unit Begins

LD2802151189 Moscow Domestic Service in Russian 1200 GMT 28 Feb 89

[Text] Aleksandr Volkov and Sergey Krikalev have been on duty in the "Mir" orbital complex for 3 months. Valeriy Polyakov, the doctor, has been working on board the space laboratory for half a year. In accordance with the geophysical experiments program, today the crew will conduct a series of experiments to determine the structure and optical characteristics of the atmosphere. Refuelling of the station's joint propulsion unit has begun, using fuel put into orbit by the "Progress-40" cargo ship. These operations are being conducted according to the commands of the on-board automatic apparatus, and are being monitored by the crew and the Flight Control Center. Medical examinations were conducted yesterday and the state of health of Volkov, Krikalev, and Polyakov is good.

'Progress-40' Undocks, Structures Deployed

LD0303112689 Moscow TASS in English 1055 GMT 3 Mar 89

[Text] Moscow March 3 TASS—By a TASS correspondent at the Ground Control Centre:

The supply craft Progress-40 was jettisoned from the Soviet orbiting station Mir at 4:46 Moscow time on Friday [3 March] after the program of their joint flight had been fully completed. It involved freight unloading, refueling and the correction of the station's orbit using the spacecraft's motors.

In an experiment after Progress-40 was undocked from Mir, two large-size multi-link folded structures on the supply craft's outer wall were automatically deployed in outer space one after another.

The technique was based on the use of form-remembering materials in these structures.

As the structures unfolded, the process was filmed and photographed by the station's crew of Aleksandr Volkov, Sergey Krikalev and Valeriy Polyakov, using a VCR camera as well as cine- and photographic equipment.

As Progress-40 continues autonomous flight, tests on the newly-deployed structures will go on to evaluate their dynamic characteristics.

Cosmonauts Describe Deployment of Structures From 'Progress-40'

Moscow KRASNAYA ZVEZDA in Russian 8 Mar 89 p 2

[Interview with cosmonauts Volkov, Krikalev, and Polyakov aboard 'Mir' station: "Radio Bridge: Space - 'KRASNAYA ZVEZDA'. Theme of the Dialogue: Afghanistan"; interview conducted by Lt Col V. Baberdin]

[Excerpt] [Interviewer:]"We still have a minute. Tell us about your work; we heard that you had an interesting experiment."

[Unidentified cosmonaut] "On Friday morning the Progress craft departed from Mir. Two containers on it opened and elements of a loop structure began floating out of two packages and opening up in space. There were rods interconnected with hinges and special wires using the shape memory effect served as the driving force. On a command from the ground an electrical supply was turned on from the Progress "space truck". The electric current caused the wires to contract and to open the elements - like the chords of a circle. So the Progress moved away from Mir with two loop frameworks at its sides. Each of them was 20 meters in diameter. The aim of the experiment was to develop the technology for assembling various structures in space. For instance, you could stretch a light-reflecting film on the framework and thus get a gigantic mirror. If you mounted connecting elements you could get a parabolic antenna. We observed how the experiment proceeded through the station viewports."

[Interviewer:]"Thank you, we understand. Until we meet again in the airways."

'Progress-40' Cargo Spacecraft Deorbited

LD0503073289 Moscow TASS in English 0720 GMT 5 Mar 89

[Text] Moscow March 5 TASS—The Soviet automatic cargo craft "Progress-40", which entered near-earth orbit on February 10, 1989, has ended its flight.

Following the commands from the Flight Control Center, the cargo craft's propulsion system was switched on at 4:08 a.m. Moscow time [0108 GMT] on Sunday. The decelerating craft changed over to the descent path, entered the dense atmospheric layers and stopped existence.

Alexander Volkov, Sergey Krikalev and Valeriy Polyakov continue their space flight.

Sunday will be the day-off for the crew.

All the three cosmonauts are feeling well. The flight of the manned station Mir is proceeding normally.

Blagov Interviewed on Future of 'Mir'

LD0503145589 Moscow Domestic Service in Russian 1200 GMT 5 Mar 89

[Interview with Viktor Blagov, deputy head of the "Mir" mission, by "our correspondent"; date and place not given—recorded]

[Text] [Correspondent] Viktor Dmitriyevich, what prospects await the "Mir" station? What lies ahead?

[Blagov] It has already done 3 years of work and I think that for another 4 years or so it will not simply exist in orbit but will in fact be providing scientific material. During that time we expect to see the arrival of another three modules in addition to the module that will arrive this year. With the arrival of every module the effectiveness of the station will be increased very strongly because the modules will deliver special scientific apparatus. The "T" module, for example—the technological module, as we call it—will be packed with special furnaces for obtaining alloys and for growing crystals. We have already carried out a great deal of work of this kind on portable installations. We have experienced a large number of critical comments and failures, like any scientific quest. But today at last we can say that the methodology for this kind of work is ready. It is possible to embark on the manufacture of industrial installations. These industrial installations are now coming out and when it arrives at the station the technological module will begin working as a micro-factory producing alloys and crystals.

[Correspondent] Viktor Dmitriyevich, the second and the third expeditions—the main ones that have been on the orbital station—were of long duration, 326 days and then one year. The present crew is returning in April. That will have been about 6 months. How long will the subsequent expeditions be?

[Blagov] A further three expeditions will be of similar duration—about 6 months or exactly 6 months—and there is a reason for this: Very simply the most expedient flight duration for an expedition is between 4 and 6 months, when the crew's productivity is sufficiently high. Afterward, fatigue builds up and the efficiency of work falls off somewhat. If you are simply talking about a pragmatic approach of that kind to the crew's performance then you should not have long flights—we should not have flights lasting longer than, say, 4 to 6 months. The crew has to be changed. From time to time, however, it will no doubt be necessary to carry out lengthy expeditions, too, insofar as today people are talking more and more frequently about starting preparations for a manned expedition to Mars. The people who fly to Mars and come back will need to spend about 2 years either in weightlessness or under artificial gravity. That question is still not yet clear now and it must be cleared up somehow. No doubt more than one crew will have to try this for 2 years—perhaps three, perhaps four or five crews—in order to build up some statistics. Long duration flights are necessary in this sense, while working flights will clearly be of 6 months.

[Correspondent] Thank you.

Experiments Continue on 'Mir' Complex

LD0703230889 Moscow TASS in English 1313 GMT 7 Mar 89

[Text] Moscow March 7 TASS—TASS correspondent reports from the Flight Control Center:

The Soviet orbital complex Mir has begun a new stage in mapping the celestial sphere in the ultraviolet part of the spectrum.

The crew used the Glazar telescope on Tuesday [7 March] to film some regions in the Centaurus constellation.

Later on Tuesday, the cosmonauts will conduct a number of geophysical experiments to study the earth's atmosphere and will replace temperature-control system fans as their service life has ended.

In accordance with a program of experiments in non-atmospheric astronomy, cosmonauts Aleksandr Volkov, Sergey Krikalev and Valeriy Polyakov have carried out several more experiments using the Rentgen observatory.

On March 6 They observed an X-ray source—a binary system in the Small Magellanic Cloud.

They have concluded a series of experiments, dubbed Mariya, to determine possible a connection between the intensity of high-energy particle fluxes and seismic activity on the earth.

During a regular communication session, the crew sent their greetings to all women of the world on International Women's Day on March 8.

'Mir' Crew Conducts Astrophysical Investigations

LD1003105289 Moscow TASS in English 1030 GMT 10 Mar 89

[Text] Moscow March 10 TASS—By Tass correspondent from the Flight Control Centre

Aleksandr Volkov, Sergey Krikalev and Valeriy Polyakov are completing another week of their space mission aboard the Mir spaceship.

On Friday the crew devoted a considerable part of their working time to astrophysical investigations. Using the "Glazar" telescope registering radiation in the ultraviolet range of the spectrum, crew members will make snaps of some parts of the celestial sphere in the Crux constellation. Several observation sessions of a Scorpio X-1 Roentgen source are planned in line with the program of the international project Roentgen.

To study the state of the human organism under space conditions, Doctor Polyakov carried out a series of medical experiments prepared jointly by Soviet and Bulgarian experts. He assessed psychophysiological responses and capacity for work of the cosmonauts and investigated interaction between the visual system and vestibular apparatus in weightlessness.

According to reports from the spaceship and the data of telemetry information, the flight of the Mir complex proceeds smoothly. The cosmonauts feel well.

Cosmonauts Continue Experiments on 'Mir' Station

LD1403124589 Moscow TASS in English 1127 GMT 14 Mar 89

[Text] Moscow March 14 TASS—TASS correspondent reporting from Mission Control Center:

The Soviet cosmonauts Aleksandr Volkov, Sergey Krikalev and Valery Polyakov on board the orbital station Mir give much time to astrophysical experiments with use of research equipment in the Kvant module.

On March 13 the crew completed another cycle of experiments. Using the Glazar ultraviolet telescope they photographed individual sections of the celestial sphere in the Coma Berenices Constellation.

The cosmonauts are continuing experiments envisaged by the international Roentgen program involving experts from several European nations. Today, they will investigate the x-ray Pulsar Hercules X-1.

To determine the best suitable regimens of physical training in conditions of endurance space flight, Krikalev will conduct an experiment known as "Sport" under close watch of Doctor Polyakov.

The cosmonauts are in good health, according to the results of medical check-ups and reports from the station.

Work on board the manned complex Mir is proceeding in accordance with schedule.

'Progress-41' Cargo Spacecraft Launched 16 March

LD1603214489 Moscow TASS International Service in Russian 2110 GMT 16 Mar 89

[Text] [No dateline as received] In accordance with the program for further work of the "Mir" scientific research complex, the automatic cargo ship "Progress-41" was launched at 2154 Moscow time [1845 GMT] on 16 March, 1989 in the Soviet Union.

The aim of the launch is to replenish materials and various cargo on the manned "Mir" complex that are being used up.

The "Progress-41" ship has been placed in an orbit with the following parameters:

Maximum distance from the surface of the earth: 260 km
Minimum distance from the surface of the earth: 193 km
Period of revolution: 88.7 minutes
Orbital inclination: 51.6 degrees.

According to telemetric information data, the onboard systems of the automatic cargo ship are working normally.

'Progress-41' Docks With 'Mir' Complex, Experiments Conducted

'Progress-41' Docks with 'Mir'

LD1803231389 Moscow TASS International Service in Russian 2250 Gmt 18 Mar 89

[Text] [No dateline as received] The docking of the "Progress-41" cargo craft with the manned "Mir" complex was carried out at 2351 Moscow time [2051 GMT] on 18 March 1989.

Mutual search, approach, the controlled final approach, and docking were carried out with the help of onboard automatic equipment. These processes were controlled by the mission control center in association with the ground command and measurement complex, and also the cosmonauts Volkov, Krikalev, and Polyakov.

The "Progress-41" craft has been docked to the complex on the side of the "Kvant" module. Fuel for the station's combined engine unit, provisions, water, equipment, apparatus, and also mail have been taken into orbit.

According to telemetric information data and reports from the crew the onboard systems of the "Mir" manned complex are working normally.

Aleksandr Volkov, Sergey Krikalev, and Valeriy Polyakov feel well.

'Mir' Experiments Conducted

LD1703233289 Moscow TASS in English 0944 GMT 17 Mar 89

[Text] Moscow March 17 TASS—TASS correspondent reports from the Mission Control Center:

A four-day cycle of scientific experiments was started on Thursday [16 March] on board the Mir orbital complex in accordance with the international Roentgen project. Their purpose is the mapping of the central part of our galaxy in the roentgen range.

Cosmonauts Aleksandr Volkov, Sergey Krikalev and Valeriy Polyakov conducted a number of experiments on studying the dynamics of the level of ionizing space radiation in the compartments of the orbital complex and along its route depending on the geophysical situation. They continued the measurement of flows of the elementary charged high-energy particles with the help of the Mariya magnetic spectrometer.

The efficiency of people's work in outer space is determined to a considerable extent by the quality of their rest and sleep. Valeriy Polyakov conducted an experiment in the course of which the quality of sleep was evaluated through electrophysiological characteristics registered with the help of the Son-k instrument created by Bulgarian specialists. On Friday [17 March] he will undergo a check-up of the cardio-vascular system during physical exercises on a cycle ergometer.

The working program included astrophysical and geophysical experiments, as well as medical control for evaluating the state of health and forecasting the cosmonauts' capacity for work in conditions of long weightlessness.

The flight of the Mir orbital complex is going on normally.

New 'Mir' Crew To Launch Within Month

LD2103134889 Moscow TASS in English 1313 GMT 21 Mar 89

[Text] Moscow March 21 TASS—By TASS Correspondent Rena Kuznetsova:

Soviet cosmonauts Aleksandr Viktorenko and Aleksandr Balandin are less than a month away from liftoff to the orbiting station Mir. They are to replace three colleagues currently working there, a ground control spokesman told TASS.

While Balandin is a relative newcomer, Viktorenko has already been aloft, leading an international Soviet-Syrian mission in July 1987.

Of the resident crew on Mir, Aleksandr Volkov and Sergey Krikalev have been in space for close on four months, with physician Valeriy Polyakov nearing the end of his seventh month in orbit.

They have done a wide range of research, nature studies, technological experiments and medical and biological tests in the interest of various economic sectors.

Volkov and Krikalev replaced Vladimir Titov and Musa Manarov who set a space endurance record of 365 days 22 hours and 39 minutes late last year.

The crew undergoing preparations will do preventive maintenance work on the station's instruments and equipment and replace some of their components. Everything needed has been delivered to the station by the latest space freighter, the unmanned Progress-41 craft.

Mir, launched more than three years ago, has been manned for over two years.

Cosmonauts Continue Astrophysical Studies, Medical Exams

LD2403104589 Moscow TASS in English 1028 GMT 24 Mar 89

[Text] Moscow March 24 TASS—By a TASS correspondent reporting from Mission Control Center: The crew of the Soviet space station Mir (Peace) will carry out maintenance operations and astrophysical and medical experiments today.

The cosmonauts Aleksandr Volkov, Sergey Krikalev and Valeriy Polyakov are continuing their endurance mission on board the orbital complex.

Using the magnetic spectrometer "Mariya", the crew are conducting a cycle of experiments to study mechanisms of the generation of high-energy particles in the earth's radiation belts and near-earth space.

Under the international project "Roentgen", the cosmonauts will conduct five sessions observing the center of the galaxy with a view to mapping out the area within an X-ray range.

Polyakov will undergo an all-round examination of his blood circulation system.

The cosmonauts will have days off on Saturday and Sunday.

'Mir' Crew Rotation Planned For End of April

LD2803085289 Moscow TASS in English 0652 GMT 28 Mar 89

[Text] Moscow March 28 TASS—Soviet cosmonauts Aleksandr Volkov and Sergey Krikalev have been working aboard the Soviet long-duration orbital complex Mir for four months. Together with them is physician Valeriy Polyakov who has been in orbit for about seven months now.

Less than a month remains before the end of the current long expedition. A change-over of space crews will take place at the orbital station at the end of April.

In Star City near Moscow, Aleksandr Viktorenko and Aleksandr Balandin are preparing for a new flight. The crew who are now in orbit will return to earth.

The cosmonauts have accomplished an extensive program of scientific research and experiments, specifically astrophysical research done by means of the Kvant specialised module of the orbital complex.

This month, for example, the cosmonauts surveyed areas of the celestial sphere in the constellation Coma Berenicis.

They performed experiments under the international program Roentgen. X-ray pulsar Hercules X-1 was one of the objects of observation. Scientific data on it are reckoned invaluable by astronomers.

Within the framework of the program for peaceful study and exploration of near-earth space for the benefit of various branches of the Soviet economy, the cosmonauts throughout the expedition engaged in space photography and made visual observations. In particular, they photographed the southern part of the European territory of the USSR to evaluate the condition of agricultural land of the Crimea, Krasnodar and Stavropol territories.

All cosmonauts are in good health, cheerful, and maintain an excellent physical trim. This is undoubtedly much to the credit of "space doctor" Valeriy Polyakov.

Mission of Next 'Mir' Crew Described

LD3103055289 Moscow in English to North America 2200 GMT 30 Mar 89

[Text] In our first item today we introduce the next crew who are to man the Soviet "Mir" orbital station. Our science correspondent Boris Belitskiy has these details.

[Belitskiy] The new two-man crew now completing their training are to be launched in the latter half of April. The crew commander Aleksandr Viktorenko already did a stint aboard "Mir" 2 years ago. The other crew member, Aleksandr Balandin, is a space rookie. They'll be taking over from the three men working aboard the station now—Aleksandr Volkov, Sergey Krikalev, and Valeriy Polyakov.

The new mission is planned for 6 months. Here's how their research program has been summed up by the crew commander Viktorenko.

[Viktorenko's voice in Russian heard in background] Viktorenko says their flight is to involve another walk in space, or to use the space jargon, another E.V.A. or extravehicular activity. On the whole, they are to continue research begun by the first, second, and third main crews aboard "Mir." This will include work with the instruments of the "Kvant" astrophysics module attached to the station. Medical research, too, is to be continued.

Viktorenko's crew mate, Aleksandr Balandin had this to say:

[Balandin voice in Russian heard in background] Balandin says the next crew, the one that will replace them aboard the station, will have the job of receiving two new modules that are to be attached to "Mir." They will also test the space bicycle, an autonomous propulsion unit to be used by cosmonauts outside their spacecraft. Balandin says their main job will include preparing the principal unit of the "Mir" station for this work, also repairing what needs to be repaired and doing preventative maintenance on the equipment so as to make the job of the next crew easier.

I would add that the new crew are also to carry out an interesting experiment in growing protein crystals for pharmaceuticals. This work is to be performed on a commercial basis for the American company Payload Systems.

Meanwhile, the present crew of the station continue working on their research program. This has lately included astrophysical and geophysical work, medical examinations of the crew members to evaluate their condition and working capacity in the context of prolonged exposure to weightlessness. According to crew reports and mission control statements, all three crew members are feeling fit and are fully coping with their research program.

Cosmonauts on 'Mir' Complex Continue Research, Medical Exams

LD3103211689 Moscow TASS International Service in Russian 1540 GMT 31 Mar 89

[Text] Moscow, 31 Mar (TASS)—TASS correspondent reports from the Flight Control Center:

During the past 2 days the flight program for cosmonauts Aleksandr Volkov, Sergey Krikalev, and Valeriy Polyakov included geophysical and astrophysical experiments and medical research.

The blood of the cosmonauts has been actually analyzed on board the "Mir" manned complex itself in order to obtain additional information on the functional state of the human organism in conditions of space flight. This work was carried out by doctor and researcher Valeriy Polyakov with the aid of the "Mikrovzor" instrument which was brought into orbit by a transport craft.

Experiments into extra-atmospheric astronomy are continuing using the X-ray telescopes of the "Kvant" module. The aim of the research which has been conducted recently is to construct an image of the central part of our galaxy in the X-ray range.

The crew's plan of work for today covers photographing specific parts of the earth's surface, the next series of "Mariya" experiments, and scheduled preventive servicing of the complex's onboard systems.

According to reports from orbit and telemetric data, the flight is proceeding normally. The cosmonauts are feeling well.

Cosmonauts Perform Experiments on Aerodynamic Drag, Medical Exams

LD0404093389 Moscow TASS in English 0907 GMT 4 Apr 89

[Text] Moscow April 4 TASS—By TASS special correspondent from the Mission Control Center:

Cosmonauts Aleksandr Volkov, Sergey Krikalev and Valeriy Polyakov go ahead with the scheduled work aboard the orbital research complex Mir. The cosmonauts performed a series of diagram experiments to determine the physical characteristics of the atmosphere near the orbital complex and to assess its aerodynamic drag. The necessary measurements were made by means of a magnetic discharge sensor put out into the open space by a rod through the airlock chamber.

They performed a regular cycle of photography of individual areas of land under the program for the study of the earth's natural resources and the environment.

Under the medical control plan the mission commander and flight engineer underwent an examination the purpose of which was to determine the bioelectrical activity of the heart in the condition of rest.

Today the space crew will engage mainly in preventive maintenance work aboard the complex. These are to replace a number of power-supply system instruments, the warranty period of which is expiring, by new ones brought by the Progress-41 cargo spacecraft.

The flight is proceeding normally. The cosmonauts are feeling well.

Activities of Crew on 'Mir' Complex Outlined

Maintenance Work

LD0604101489 Moscow Domestic Service in Russian 0600 GMT 6 Apr 89

[Text] Report from the Flight Control Center: The cosmonauts Aleksandr Volkov, Sergey Krikalev, and Valeriy Polyakov will be engaged for the most part today in planned preventive work with the station's equipment and onboard systems. It is intended in particular to replace certain units and assemblies whose guarantee period is expiring. According to the crew's reports and telemetric data everything on board is in order. The cosmonauts' health is good, and they are feeling well.

Experiments Conducted

LD0704164889 Moscow TASS in English 1334 GMT 7 Apr 89

[Text] Moscow April 7 TASS—TASS Correspondent reports from the Flight Control Center:

Aleksandr Volkov, Sergey Krikalev and Valeriy Polyakov continue work aboard the orbital complex Mir.

The program of the crew's work this week involved geophysical and technical experiments and also medico-biological research. They also carried out maintenance work on separate systems and equipment of the complex.

With the aid of the apparatus Circe, which was developed by French specialists, the cosmonauts performed a series of experiments to assess the dynamics of space radiation level in near-terrestrial space depending on solar activity.

Today the crew will have another session of photographic scanning of the earth's surface, check the complex's radioengineering communication systems with the Flight Control Center via ther relay satellite. During the day they are to pump water from the tanks of the Progress-41 freighter into the tanks of the station.

The cosmonauts feel well. On Saturday and Sunday they will rest.

'Mir' Cosmonauts Prepare for Return, Flight to Continue Unmanned

LD1104150189 Moscow TASS International Service in Russian 1425 GMT 11 Apr 89

[Text] Moscow, 11 April—A TASS correspondent reports from the Flight Control Center:

The long orbital flight of Soviet cosmonauts Aleksandr Volkov, Sergey Krikalev, and Valeriy Polyakov is nearing completion.

Today's working program of the "Mir" orbital complex includes the stock-taking of equipment and of the materials that are being used, scheduled and preventive maintenance, and checking of onboard systems.

In the coming days, the replenishing of the fuel tanks of the base unit with the fuel and oxidizer delivered by the Progress-41 craft is to be carried out as well as the mothballing of the station's onboard systems.

After the correction carried out yesterday, the orbital parameters of the "Mir" complex are:

—apogee - 400 km;
—perigee - 372 km;
—period of revolution - 92.1 mins;
—inclination - 51.6 degrees.

It has been planned that the cosmonauts should return to earth on 27 April. The "Mir" orbital complex will continue its flight in the automatic mode.

'Mir' To Be Left Unmanned Due to Module Delay

LD1204194989 Moscow TASS in English 1854 GMT 12 Apr 89

[Text] Moscow April 12 TASS—When three Soviet cosmonauts return back to earth from their orbiting station Mir in about a fortnight, the facility will be left unmanned for several months due to delays with the preparation of two research modules for it, a Soviet space official said today. [Moscow TASS International Service in Russian at 1556 GMT on 12 April in a similar report identifies the problem and the two modules more specifically by saying that there has been a "delay in the manufacture and delivery to orbit of modules: a re-equipping module and a technological module."]

Deputy Flight Director Viktor Blagov told TASS that Aleksandr Volkov, Sergey Krikalev and Valeriy Polyakov are to land on April 27 and that there will be no immediate change-over of crews on Mir.

This is because without the two modules, which will make it possible to conduct wide-ranging research, including studies in the interest of the Soviet economy, there is little sense in keeping cosmonauts on the space station any further, he explained.

The break, however, will have its advantages, helping prepare for the coming research work more thoroughly, Blagov added.

"New economic support on board Mir and on the ground, new documentation and new training are needed. It is fairly difficult to do this in the course of a manned flight. So the adjournment will simplify many things," he said.

Commenting on recent calls by some representatives of the public to make deep cuts in spending on space exploration, he said the effect would be the about the same as earlier clampdowns on cybernetics and genetics.

Soviet space technology is up to the highest world standards but industrial spin-offs are pitifully scanty as very few of the space industry's achievements are turned over for commercial use, Blagov said.

He called for speedier transfers of ideas and developments from the space sector to other industries.

And serious steps are already being taken to rectify the situation, the space official added.

"We plan to promote space commercial services and have already begun to do this: Of the 19 agreements signed by (the Soviet space agency) Glavkosmos with other countries and foreign firms, ten have been carried out," Blagov said.

He said that more and more such projects will be pursued.

Mir, launched more than three years ago, has since hosted three resident and four guest crews, including cosmonauts from Syria, Bulgaria, Afghanistan and France as well as Soviet spacemen Vladimir Titov and Musa Manarov who have spent a record one year in orbit.

Their colleagues Aleksandr Viktorenko and Aleksandr Balandin are in training for their turn on the space station.

UDC 551.510.535.2

Patterns of Stratification of Birkeland Current Systems (Coordinated Experiments Within Framework of ARCAD-3 Project)

18660052a Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 5, Sep-Oct 88 (manuscript received 2 Mar 87) pp 709-724

[Article by Ye. Ye. Timofeyev, O. M. Raspopov, Yu. I. Galperin, N. V. Dzhordzhio, A. Berthelier, J. J. Berthelier, J. M. Bosqued, M. K. Vallinkoski and R. I. Pellinen]

[Abstract] The results of coordinated measurements carried out from the Aureol-3 satellite (ARCAD-3 project) and from surface geophysical stations on the Kola Peninsula and in Scandinavia, under conditions of observation of longitudinally extended stable homogeneous arcs at the equatorial boundary of the oval, were used in defining a three-dimensional current system ("loop") characteristic for an L structure ("inverted V" type) of electron injections. The system consisted of a pair of layered longitudinal currents of opposite direction, closed by an ionospheric current ("Bostrom" loop). The direction of the meridional component of the ionospheric closing current was determined by the direction of the large-scale ionospheric current closing the longitudinal currents of zone 1/zone 2. The strongest current loop from the series of L structures in the evening and near-midnight local-time sectors was situated at the boundary between zone 1 and zone 2. A stable homogeneous arc (preliminary substorm phase) was situated at the equatorial edge of a series of L structures (at the equatorial boundary of the region of the ascending longitudinal current) when the meridional ionospheric current was directed poleward. Three cases of measurements from other satellites when there were stable homogeneous auroral arcs over this region are also examined. All the considered cases of observation of stable homogeneous arcs in the evening, near-midnight and morning sectors of local time are in qualitative agreement with the unified scheme of "embedded current loops" of different scales. Figures 5; references: 34 Western.

UDC 550.388:537.221

Surface Diagnostics of State of Medium During Disturbances of Charging of Geostationary Satellite

18660052b Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 5, Sep-Oct 88 (manuscript received 18 Jun 86) pp 725-730

[Article by Yu. I. Vakulin, O. S. Grafodatskiy, L. G. Danilova, V. I. Degtyarev, G. A. Zherebtsov, A. G. Kozlov, G. M. Markelov, G. V. Popov, Sh. N. Islyayev, V. I. Guselnikov, A. A. Kocheyev and L. L. Frumin]

[Abstract] Surface geophysical observations were used in evaluating the state of the medium during disturbances of the charging of the "Gorizont" geostationary communication satellite. Cases of charging of a space vehicle under the influence of the surrounding medium can be classified into two morphological types (sporadic (or anomalous) charging registered as an abrupt (up to several hours in duration) satellite charging and a smooth diurnal variation of spacecraft charging. Disturbances of spacecraft charging occur at times when the spacecraft enters into the hot thermal plasma layer and at the same time there are substorm disturbances of fluxes of high-energy particles in the neighborhood of the spacecraft. A substorm disturbance of fluxes of high-energy particles and the density of hot thermal plasma, beginning near the midnight meridian, reaches the spacecraft with some lag; a similar lag is present in riometer absorption and in the H component of the magnetic field at Norilisk, but since Norilsk is situated to the east of the spacecraft the lag is less. As a result, manifestations of substorm activity registered at Norilsk outpace disturbances of spacecraft charging and serve as predictors. A more detailed study of the state of the surrounding medium at the times of anomalous charging of a satellite requires use of data from a meridional chain of surface observatories, which ideally should be situated on the meridian of a geostationary satellite. Figures 2; references 7: 2 Russian, 5 Western.

UDC 629.195.1

Simulation of Effects Associated With Influence of Magnetic and Solar Shadow From Satellite Structural Elements on Results of Measurements of Electric Fields and Particle Fluxes

18660052c Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 5, Sep-Oct 88 (manuscript received 5 Mar 87) pp 731-737

[Article by M. M. Tsonev and G. A. Stanev]

[Abstract] A program is proposed for computing the position of solar and magnetic shadows in the vicinity of a satellite that are cast by its structural elements and, in particular, the times of entry of the sensors of the scientific instruments into this shadow. The computations made for the "Intercosmos-Bolgariya-1300" satellite are compared with the results of measurements of electrical field and fluxes of charged particles made on this same satellite. The universal SKY program for determining the solar and magnetic shadows cast by structural elements at an arbitrary point in the vicinity of the satellite was written for the purpose of solving the problem of simulating the satellite structure and determining the intervals of disturbances in the operation of the scientific instrumentation. The program makes use of data on the orbital parameters of the satellite in a specific time interval. The input parameters—the geographical coordinates of the satellite and the direction of the magnetic induction vecto—are transformed from a topocentric system to an orbital coordinate system. The position of the solar cells is determined from data on orientation on the solar disk. For each specific session it is possible to obtain a short list of the times of entry into and emergence from the solar and magnetic shadowing

of the considered sensors with an indication of the shading elements or a detailed printout of situations for the entire session. In the second case there is indication of which of the selected instruments or control points fall in the satellite shadow. In both cases information on the minimal proximity of solar cells, on intersection of the terminator and on entry into the Earth's shadow (or emergence from it) is sent simultaneously to instrument sensors for measuring the electrical field. Only the "shadow" along the magnetic lines of force is computed for those cases when the satellite is in the Earth's shadow and is accordingly not directly illuminated by the sun. It is shown that some peculiarities of experimental data can be attributed to shading of instrument sensors and can be used in increasing the reliability of the collected scientific information. Figures 4; references 8: 1 Russian, 7 Western.

UDC 551.510.536

Specialized Aeronomic Model for Research on Artificial Modification of Middle Atmosphere and Lower Ionosphere. 1. Requirements on Model and Fundamental Principles for Its Construction
18660052d Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 5, Sep-Oct 88 (manuscript received 20 Sep 87) pp 738-745

[Article by S. I. Kozlov, V. A. Vlaskov and N. V. Smirnova]

[Abstract] The possibility of development of specialized aeronomic models making it possible to investigate the behavior of the medium under the influence of the most different sources of artificial disturbance of the Earth's atmosphere and ionosphere is discussed from unified theoretical and methodological points of view. The requirements imposed on a universal aeronomic model are concisely formulated and are summarized in Table 1; Table 2 lists the input parameters and parts of the model. One of the first models formulated for the altitude range 30- 100 km is described. This model has a number of limitations on its use for studying various artificial disturbances at h [<] 100 km, of which the most important are: requirement on a constancy or insignificance of variations of pressure and temperature; the total computation time must not exceed 4-5 hours, since otherwise the changes in minor neutral and excited components may be caused by a change in solar radiation and may be unrelated to artificial disturbance of the medium; the model does not reproduce sunrise-sunset conditions. The simultaneous variation of different input parameters with the inclusion (or exclusion) of different independent parts of the model will make possible an examination of a qualitatively new class of problems related to behavior of the middle atmosphere and lower ionosphere under conditions of the combined influence of sources of artificial disturbance. References 18: 14 Russian, 4 Western.

UDC 581.521

Ion Ring Current During Magnetic Disturbances Determined From Observation in Geostationary Orbit. 2. Variations in Energy and Charge Spectra of Ions During Moderate Storms
18660052e Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 5, Sep-Oct 88 (manuscript received 10 Feb 87) pp 746-752

[Article by N. A. Vlasova, A. S. Kovtyukh, M. I. Panasyuk, E. N. Sosnovets, O. S. Grafodatskiy, Sh. N. Islyayev and A. G. Kozlov]

[Abstract] Variations of the spectral characteristics of protons and ions of the group $[C, N, O]^Q$ with Q greater than or equal to 2+ in the energy range of more than tens of keV/e during the time of different phases of moderate geomagnetic storms are analyzed on the basis of data from the "Gorizont" (1985-07A) artificial earth satellite. The variations of the energy spectra of ions during the storm of 27-28 February 1985 are compared with a similar analysis of the storm of 12-13 August 1985. The principal conclusions which follow from an examination of the energy and charge spectra during these storms are as follows. During the main phase there is a change in the charge composition of $[C, N, O]^Q$ ions that is due to enrichment by ions with small charges. During the main phase of the storm there are no substantial changes in the energy spectra of multiply charged ions, whereas the proton spectra become harder because, for the most part, of an increase in the fluxes of high-energy particles. The filling of the geostationary orbit with multiply charged $[C, N, O]^Q$ ions begins at the onset of the restoration phase and occurs predominantly on the nighttime side; this later results in an increase in the relative content of multiply charged ions on the daytime side as well. Figures 5; references 8: 4 Russian, 4 Western.

UDC 537.591

Cosmic Ray Research on 'Venera-15' and 'Venera-16' Automatic Interplanetary Stations
18660052f Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 5, Sep-Oct 88 (manuscript received 27 Feb 87) pp 753-761

[Article by Ye. A. Chuchkov, N. V. Pereslegina, G. P. Lyubimov, V. I. Tulupov, S. I. Yermakov, N. N. Kontor, Yu. A. Rozental, V. B. Kadobnov, T. I. Morozova, N. N. Pavlov, A. I. Rutkovskiy, G. A. Rutkovskaya and M. A. Ovsyannikova]

[Abstract] This is a review of the data of measurements of the characteristics of low-energy cosmic rays obtained using instrumentation carried aboard the automatic

interplanetary stations "Venera-15" and "Venera-16" during the period 7 June 1983-30 April 1985. Proton fluxes with energies 1.2- 10, 1.2-66, 5.2-8.1 and [>]30 MeV and α-particles with energies 6.6-24 MeV were registered. The article gives specifications of the instrumentation and the mean diurnal intensities of cosmic rays. Attention is directed to the period from February through May 1984 during which strong increases in the intensity of solar cosmic rays were registered and the Earth-Sun-spacecraft longitude angle changed from 100 to 170°. The long-term variation of the intensity of galactic cosmic rays on the station and the Earth is compared. Two large-scale intensity variations registered in 1984 are discussed. The data from two-year continuous measurements of the intensity of cosmic rays in interplanetary space in a Venusian orbit during the descending phase of the 21st cycle of solar energy, in the interval of its local activity maximum, show that it is comparable in magnitude to the entire 20th cycle. During the experiment the station, moving in the same direction as the Earth, made a total revolution around the sun. The station instruments registered effects from solar flares which were not visible from the Earth. The registry of disturbances of the interplanetary medium and streams of solar cosmic rays at two points (station and artificial satellite) simultaneously revealed a strong dependence of the effects on heliolongitude distance between the station and the Earth. There was a large-scale effect of anisotropic modulation of galactic cosmic rays at the end of 1984. Figures 3; references 11: 10 Russian, 1 Western.

UDC 551.521.6

Neutron Flux Measurements on 'Salyut-6' Orbital Station

18660053g KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 5, Sep-Oct 88 (manuscript received 12 Nov 86) pp 793-796

[Article by B. Yu. Yushkov]

[Abstract] Neutron fluxes in the energy range from thermal to several MeV were measured in 1977-1982 on the orbital space station "Salyut-6." The total flux of neutrons registered on satellites is equal to the sum of fluxes of albedo and local neutrons. The fluxes of local neutrons can be divided into two groups on the basis of origin: those generated in the matter of the satellite and detector under the influence of high-energy protons of the Earth's inner radiation belt and observed at altitudes of 300-400 km exclusively in the South Atlantic anomaly; and neutron fluxes generated under the influence of primary high-energy cosmic rays and secondary radiation associated with primary cosmic rays. The second group should have the same latitude dependence as the albedo neutrons. Figure 1 illustrates the presence of these two substantially differing groups of registered neutrons. These data are discussed in detail on the basis of numerous observations made at different times in order to clarify and explain the neutron fluxes observed in the "Salyut-6" measurements. Figure 2 illustrates the dependence of the neutron counting rate on geomagnetic latitude for July-August 1978, April 1979, June-August 1980 in comparison with computations and measurements made on the OGO-6. The "Salyut-6" measurements exhibited no dependence on the phase of the solar activity cycle. The contribution of albedo and local neutrons to the detector counting rate was ascertained. The contribution of albedo neutrons is 2/3. Figures 2; references 11: 5 Russian, 6 Western.

Booster Rocket Launches 6 'Cosmos' Satellites

LD1102091589 Moscow TASS in English 0906 GMT 11 Feb 89

[Text] Moscow February 11 TASS—Six satellites in the Cosmos series—Cosmos-1994, Cosmos-1995, Cosmos-1996, Cosmos-1997, Cosmos-1998, Cosmos-1999 were launched by a Cyclone booster rocket in the Soviet Union on Friday [10 February].

The satellites carry scientific equipment for a continuation of space research. All the six satellites travel in orbits which are close to planned ones with the following initial parameters:

Orbital period—114.1 minutes,
The maximum distance from the earth's surface—1,442 kilometres,
The minimum distance from the earth's surface—1,403 km,
Orbital inclination—82.6 degrees.

The satellites also carry radio systems for precision measurement of orbital elements and radio telemetric systems to transmit back to earth the data on the operation of instruments and scientific equipment.

The onboard equipment is functioning normally.

'Cosmos 2002' Satellite Launched 14 February

LD1502084489 Moscow TASS in English 0838 GMT 15 Feb 89

[Text] Moscow February 15 TASS—The Soviet Union has launched another satellite, Cosmos 2002, on Tuesday [14 February].

The satellite was launched by a Cosmos rocket booster and is equipped to carry out space research.

The parametres of the satellites orbit are as follows: initial revolution period—110.4 minutes, maximum distance from the earth's surface (in the apogee)—2,315 kilometres, minimum distance from the earth (in the perigee)—187 kilometres, orbit inclination—65.8 degrees.

The satellite has a radio system to measure the orbit's characteristics precisely and a radiotelemetry system to transmit data back to earth about the functioning of the scientific equipment.

The satellite's equipment is functioning normally.

'Spectrum-Roentgen-Gamma' Project Planned for 1993

18660090 Moscow APN: ADVANCES OF SCIENCE AND TECHNOLOGY in English
No 33, 25 Nov 88 pp 1-3

[Article by Yuriy Zaytsev, chief of information department, Institute of Space Research, USSR Academy of Sciences: "'Spectrum-Roentgen-Gamma'—A New Space Project"; first paragraph is source introduction]

[Text] A research project in the field of high-energy astrophysics, being planned by Soviet scientists and entitled "Spectrum-Roentgen-Gamma", is set to achieve a new level international cooperation. Taking part in the project's preparation today are specialists from Australia, Bulgaria, Britain, Hungary, GDR, Denmark, Italy, Canada, Poland, Portugal, USA, Finland, France, FRG, Czechoslovakia, Japan and the European Space Agency. The following is a description of the project by Yuriy Zaytsev, Chief of the Information Department, Institute of Space Research, USSR Academy of Sciences.

Realization of the project will amount to a significant step forward in throwing light on numerous physical phenomena in the Universe, which have not yet been thoroughly understood. The instruments installed at the new orbital observatory are expected to furnish unique information on galactic sources of X-ray radiation: neutron stars in the double stellar systems, supernovae remnants, hot interstellar gas, supermassive "black holes" in active galactic nuclei, intergallactic gas in galactic clusters. A significant surface area of collecting mirrors in the X-ray telescopes, an extremely wide range of measuring X-ray quanta energies, a possibility of constructing high-resolution X-ray images and of carrying out X-ray spectroscopy open up the greatest opportunities for using the orbital observatory in solving fundamental cosmological problems.

The authors of the project are planning to be engaged in searching for remotest quasars—these exceptionally bright star-like formations, the radiation from each of them being not inferior in power to that from an entire galaxy comprising hundreds of billions of stars. One such mysterious source, designated OX-169, in the space of only three hours is observed to double the brightness of its X-ray radiation. Thus it appears that in its dimensions it is not larger than the Solar system, or, more likely, is half its size. The heaviest black hole of such dimensions would have a mass of about 200 million suns. There have by now been discovered a great many quasars, but the question about the reason for such a tremendous energy output remains unsolved.

The observatory will have access to hundreds of thousands of superweak X-ray sources lying at the boundary of the observed Universe. Their detailed study will throw additional light on the problem of the diffusive X-ray background. The point is that the sky in the X-ray range does not look dark. There is a background "blurred" radiation comparable to that from discrete sources. It is presumed to be emanating from a rarefied hot intergallactic gas filling up all space. If this is so, then from the magnitude of the diffusive background we may judge the Universe's average density and, consequently, the nature of our world, whether it is "closed" or "nonclosed", i.e. whether the observed expansion of the Universe will ever be replaced by compression or whether it will continue indefinitely.

An important task of the project will also be the study of transient (disappearing) X-ray sources and gamma-outbursts.

One of the principal instruments in the "Spectrum-Roentgen-Gamma" observatory will be the Soviet-Danish telescope incorporating X-ray optics of so-called oblique incidence. The total surface area of the X-ray mirrors in the two identical telescopes will be 130 square metres. The sensitivity of the telescope will be 20 times as high as that of the telescope installed on the USA's Einstein satellite. It is not surprising, therefore, that scientists are looking forward to obtaining from the new space laboratory a wealth of new, possibly even quite unexpected, information.

The telescopes are planned to be brought into outer space in a folded position, to be then opened up in orbit. Their focal distance is 8 metres and it will be possible to change it. The angular resolution is 2 minutes of arc.

Design and manufacture of the telescope's optical structure, including the unfolding mechanism, are being executed by Soviet specialists. They will make all calculations of the telescope's thermal and mechanical characteristics, as well as test it by imitating operational conditions aboard the spacecraft. Specialists from the USA, Finland and some other countries are also willing to contribute to developing the telescope. Thus, in Czechoslovakia a system for replacement and accurate training of the telescope focal detectors is being designed.

One more oblique-incidence telescope is intended for accurate localization, spectroscopy and plotting of images of weak X-ray sources, its resolution being 10 seconds of arc. It will comprise an optical monitor with a 30-centimeter diameter mirror and a device of so called charge feedback. This is a single silicon crystal the surface of which contains hundreds of thousands of sensors. Light collected and amplified by the mirror will fall onto them to be converted into electric signals proportional to light intensity in the given part of the image. Photoplates which have always been a kind of standard supplement to ground-based astronomical

cameras record only seven out of every thousand of light quanta. The device with a charge feedback is capable of recording 700 out of a thousand.

Accessible to the optical monitor will be thousands of stars from each observation position, even those of the 20th and 21st magnitude. This will make easier an optical identification of X-ray objects and will enable their variability in the X-ray and optical ranges to be studied synchronously.

Construction of this second telescope is today a joint undertaking of specialists from Britain, Italy, USSR, FRG, and the European Space Agency.

Thus, the observatory's two principal instruments supplement one another: the Soviet-Danish telescope, because of the large collecting area of the mirrors, will be capable of engaging in detailed spectroscopy of relatively weak sources, whilst the second instrument, because of a high angular resolution, is expected to yield record-breaking results in prolonged far-reaching scannings of the sky and in the observations for superweak objects. The principal tasks facing these instruments are associated with extragalactic astronomy and cosmology.

Along the observatory's main axis a telescope being built by Soviet scientists will be set up, with a coding mask intended for constructing the images and for spectroscopy of sources in the hard X-ray range. Its angular resolution is 7 seconds.

The specialists from the USSR, the GDR and Britain are cooperating in designing a "normal incidence" telescope EUYITA for observing sources within the maximum ultraviolet range and for studying the interstellar medium homogeneity. Its angular resolution is 10 seconds.

The rotary platform is going to accommodate a Soviet-built telescope for plotting the images and for spectroscopy of bright X-ray sources. Determination of the rotary platform coordinates will be made possible by means of a stellar sensor now being developed in Bulgaria. It will be simultaneously employed for optical observations of X-ray sources.

The "Spectrum-Roentgen-Gamma" laboratory is planned to be brought into a strongly-elongated orbit with initial altitudes in the perigee 500-1000 km and in the apogee 200 thousand kilometers. The length of the orbital working stretch will in this case be 3-4 days.

"It is expected that the "Spectrum-Roentgen-Gamma" orbital observatory will yield several billion units of information daily," says the science chief of the project from the Soviet side Rashid Syunyaev, Corresponding Member of the USSR Academy of Sciences. "This information is too great to be fully processed by any single computing centre or any single research group. We are counting on the acceptance of a system of competitive applications for observations. This will give access to participation in the project to a great many observatories, institutes and universities. [quotation marks as published]

Launching of the space observatory is planned for 1993. There can be no doubt that the analysis of the obtained data will greatly contribute to our knowledge of the "Big World" which appears to be much more curious than we have assumed it to be quite recently.

UDC 324.352

Increase in Flux of Hard X-Radiation From Supernova 1987A Determined by 'HEXE' and 'Pulsar X-1' Instruments in 'Rentgen' Observatory on 'Kvant' Module

18660088a Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 14 No 7, Jul 88 (manuscript received 22 Mar 88) pp 579-590

[Article by R. A. Syunyayev, V. V. Yefremov, A. S. Kaniovskiy, D. K. Stepanov, S. N. Yunin, A. V. Kuznetsov, V. M. Loznikov, A. S. Melioranskiy, V. G. Rodin, A. V. Prudkoglyad, S. A. Grebenev, C. Reppin, V. Pietch, Ya. Engelehauser, J. Trumper, W. Voges, E. Kendziorra, M. Bezler and R. Staubert, Space Research Institute, USSR Academy of Sciences, Moscow; Exoatmospheric Physics Institute, Max Planck Society, Garsching, West Germany; Astronomical Institute, Tubingen, West Germany]

[Abstract] The supernova 1987A, observed from August 1987 through February 1988 using the "HEXE" and "Pulsar X-1" instruments on the "Kvant" module of the "Mir" space station, indicated an appreciable increase in the intensity of hard X-radiation of the supernova in the range 20-400 KeV. The observed emission spectrum of the supernova and the rate of growth can be explained only in models related to comptonization of the gamma lines forming during the decay of radioactive cobalt. The early appearance of emission in cobalt lines and the relatively slow increase in intensity are indicative either of an appreciable mixing of cobalt through a considerable part of the cast-off envelope or a considerably aspherical geometry of the supernova envelope. Figures 7; references 12: 3 Russian, 9 Western.

UDC 524.352

Upper Limits on X-Radiation of Supernova 1987A in Range 2-32 KeV in June-August 1987

18660088b Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 14 No 7, Jul 88 (manuscript received 24 Mar 88) pp 591-593

[Article by R. A. Syunyayev, M. R. Gilfanov, Ye. M. Churazov, N. S. Yamburenko, A. K. Brinkman, J. Heise, J. J. M. Int Zand, R. Jager, G. K. Skinner, O. Al-Emam, T. G. Patterson and A. P. Willmore, Space Research Institute, USSR Academy of Sciences; Space Research Laboratory, Utrecht, Netherlands; Birmingham University, Great Britain]

[Abstract] Prior to detection of X-radiation of the supernova 1987A in August 1987 the field of the Large Magellanic Cloud was investigated by several X-ray

telescopes. The strongest upper limits on the flux from the supernova 1987A in the range 2-32 KeV in June-August 1987 were obtained by the TTM instrument installed in the "Kvant" module of the "Mir" station. The TTM is a telescope with a coding aperture which makes it possible to obtain an image of a sector of the sky 7.8° x 7.8° with an angular resolution of about 2 minutes of angle in the energy range 2-32 KeV. The effective area for the source at the center of the field of view is about 200 cm^2. Over the course of 3 months there were 68 successful TTM pointings on the Large Magellanic Cloud with a total observation time of about 47 000 s. Analysis of these data did not reveal a significant flux from the supernova in the indicated range. Data for this series of observations are given and are compared with the results of observations by other instruments in this same range, including for the period of X-radiation detection. Figure 1; references 7: 1 Russian, 6 Western.

UDC 524.35

Search for Gamma Radiation From Supernova 1987A in Experiment on 'Salyut-7'—'Cosmos-1686' Orbital Complex

18660088c Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 14 No 7, Jul 88 (manuscript received 1 Apr 88) pp 594-598

[Article by R. N. Vasilova, G. M. Blokh, V. M. Pankov, V. L. Prokhin, A. I. Rutkovskiy and S. P. Ryumin, Nuclear Physics Scientific Research Institute]

[Abstract] Systematic measurements of gamma quanta fluxes in the energy range 1.5-4.4 MeV were made at an altitude 500 km in the equatorial region during the period February-October 1987 with the "Nega" instrument on the orbital complex "Salyut-7"—"Cosmos-1686" for the purpose of seeking radiation from SN 1987A. The detector of the "Nega" instrument is a cylindrical CsI(Tl) scintillator with a diameter and height 8 cm, shielded on all sides. With a change in latitude the counting rate with the gamma quanta instrument changed by a factor of 3- 4.5; the search for SN 1987A gamma radiation was therefore made in equatorial segments of the orbit when the counting rate and temporal variation were minimal. Mean values for a month were used in the search for gamma rays. Figure 1 shows the dependence of the flux of gamma quanta measured with the "Nega" instrument in the neighborhood of the equator on time. Figure 2 shows the dependence of the flux of gamma quanta at the equator on the flux of cosmic rays measured in the stratosphere at Moscow. These data are analyzed. The gamma radiation of SN 1987A is exceptionally interesting because for the first time it has afforded possibilities for direct checking of the theoretical prediction of formation of ^{56}Ni in a supernova explosion and for tracing the evolution of its escaping envelope in time. The upper limit of the flux of gamma quanta in the energy range 1.5-4.4 MeV was 1.5 x $10^{-6}cm^{-2}s^{-1}KeV^{-1}$ at the 3σ level. The "Salyut-7"—"Cosmos-1686" data do not contradict gamma radiation flux measurements published in other sources. Figures 2; references 8: 4 Russian, 4 Western.

'Phobos' Probe Measures Martian Surface

LD0302145389 Moscow TASS in English 1447 GMT 3 Feb 89

[Text] Moscow February 3 TASS—The interplanetary probe Phobos put into orbit of a Martian artificial satellite, started explorations.

On February 1 the probe conducted a measuring session when it passed the Martian surface at the closest distance. Instruments of the plasma and wave system and magnetometers operated during the session. The probe also registered infrared and gamma radiation of the planet. Information is being processed by participants in the experiment. It is planned to conduct several more sessions of this type on this orbit.

'Phobos' Satellite Placed In New Intermediate Orbit

LD1202172989 Moscow TASS in English 1722 GMT 12 Feb 89

[Text] Moscow February 12 TASS—TASS correspondent reports from the Mission Control Center:

The Phobos automatic interplanetary station which became an artificial Mars satellite on January 29 has been transferred to a new intermediate orbit. Another maneuver was carried out which ensured a steady rapprochement of the interplanetary station and Phobos.

In accordance with a flight program, the station's engine was turned on at 1600 Moscow time on February 12, which gave it additional impetus and ensured the transfer to a new elliptical orbit with the following parameters:

—Maximum distance from Mars's surface (apocenter)—81,200 km,
—Minimal distance from Mars's surface (pericenter)—6,400 km,
—Inclination with regard to the Mars equator—0.9 degrees,
—Period of revolution around the planet—86.5 hours.

During the flight on this orbit the station will continue comprehensive observations of the surface and atmosphere of Mars, as well as the space around the planet, that were started on February 1st and continued on February 5, 8 and 11.

In the future, after the parameters of the station's movement are specified, it will be transferred to a circular orbit with a radius which will exceed by 200-300 kilometres the height of the orbit of the Phobos satellite. From this distance the station will carry out autonomous

navigation measurements of the position of that satellite of Mars for the purpose of a subsequent rapprochement of the station and the satellite.

International Experts Discuss 1994 Mars Mission, Current 'Phobos' Program

LD1302161688 Moscow TASS in English 1415 GMT 13 Feb 89

[Text] Moscow February 13 TASS—Some six weeks before a Soviet space probe approaches a Martian moon as the climax of the Phobos project, an international meeting of scientists opened here on Monday to discuss the next mission to the red planet in 1994.

The experts attending the meeting are from more than ten countries and are reviewing the program of experiments and equipment for the project which will also be based on extensive international cooperation.

In the meantime, the space probe Phobos-2, which lifted off on July 12, 1988, and reached the orbit of Phobos on January 29, on Sunday shifted to a still lower orbit around the Martian moon to continue comprehensive experiments started on February 1, 5, 8, and 11 to investigate the Martian surface and atmosphere as well as outer space in the vicinity of the red planet.

The probe's sister craft Phobos-1, which was launched from Baykonur space port five days before it, tumbled out of control when an erroneous command was sent to it during a communications session on August 29, turning its solar cell arrays away from the sun.

As a result, Phobos-1 ran out of power and did not react to commands during the following communications session.

Apart from examining the 1994 mission, scientists at the Moscow meeting are adjusting the current project following the loss of one of the two space craft involved.

At the beginning of next April all the 28 thrusters of Phobos-2, which will then be within 50 kilometers of the Martian moon, will be fired to bring the probe as close as 50 meters from the surface of Phobos.

During the subsequent 25-minute flight at the same altitude it will, among other things, take panoramic pictures of Phobos' surface and sense it by means of a laser.

A laser beam will evaporate and ionise a speckle of soil, which will then be tested by the craft's instruments. At the end of the low-altitude drift Phobos-2 will drop two instrument-packed modules, one of which will remain anchored on the surface, while the other will hop about to explore the terrain.

The modules will stay operational for a long time, testing the ground and studying celestial mechanics.

Ksanfomaliti Interviewed on 'Phobos' Project, Plans for Mars

LD1302232988 Moscow Domestic Service in Russian 1900 GMT 13 Feb 89

[Text] A session of the council on the Phobos space project was held in Moscow today. Let us recall that it envisages the study of Mars and its satellite Phobos, using instruments mounted on automatic stations. Contact with one of these was lost during the 200-day flight to the planet, while the second one entered orbit around Mars' satellite and began the study. Our correspondent interviewed Leonid Vasilyevich Ksanfomaliti, doctor of physical and mathematical sciences.

[Begin recording] [Unidentified correspondent] Leonid Vasilyevich, we waited impatiently for half a year for the stations to reach the vicinity of Mars, and this happened. It is, of course, difficult to speak about any results, even preliminary ones, but communications sessions have already been conducted with the station and some information has already been received at the Space Research Institute. We journalists are always in a hurry.

[Ksanfomaliti] I want to correct you immediately. You say that we have been waiting for half a year. It is you who have waited half a year; we have waited about 10 years, because our experiment was planned 10 years ago, and the same applies to many other experiments. In general, it should be said that the time spent on creating a device, on its flight to a celestial body in space, and on obtaining these results is only the initial stage of our work. Unfortunately, it takes weeks, months, and years of work to comprehend what is happening on that distant planet and to comprehend what has been obtained in this experiment. When you become accustomed to the problem you can say what is happening. Now, in a number of experiments, both directly connected with the planet itself and connected with the planet's atmosphere, the planet's near surroundings, charged particles, and magnetic fields, much that is new has been obtained. The scientists are attempting to comprehend this new material and to somehow link it to previous ideas; after all, it is not the first time we have flown to Mars. And each such flight reveals only little by little the information about the planet which we really want to obtain.

Now that studies have been conducted on the previous apparatus, we know that Mars has proved to be a very complex planet. A number of newly discovered phenomena show that on Mars, for example, there has been a powerful movement of shift of the entire crust relative to the polar axis. The axis evidently crossed Mars where the equator is now situated. In order to study the structure of the equatorial area, to study how the surface itself is arranged, to study the proportions of stone, rocky outcrops, and sand there, we are now attempting to mount experiments in radiometry, for instance. These experiments are in operation. We are obtaining some results which we later have to comprehend. In addition to the

results which it will be possible to interpret as results relating directly to the physics of Mars, they also have simply pragmatic benefits. In the not-too-distant future a Soviet "Marsokhod" vehicle will clearly be traveling over Mars. [end recording]

Sagdeyev Sees Manned Mars Mission in 2010-2015 Time Period

LD1302215489 Moscow Television Service in Russian 1800 GMT 13 Feb 89

[From the "Vremya" newscast; interview with R.Z. Sagdeyev, head of the Phobos Space Project, by reporter P. Orlov, at the Space Research Center in Moscow; date not given]

[Excerpt] [Passage omitted] [Orlov] Will what has now been accomplished make it possible for man to get to Mars more confidently? For that is what we are after.

[Sagdeyev] Well, I think there's still a long way to go, but it will make it possible to continue moving more confidently toward that target. But I think now, after the fulfilment of this project [Phobos], our task is to select the most effective and economically feasible design for the next unmanned craft. They must be cheap unmanned craft, but each step must, as in acupuncture, be in just the right place and must answer the most important questions. I think that really after two or three unmanned missions—comparatively cheap unmanned ones—we will get a manned expedition somewhere in the year 2010 or perhaps 2015. [passage omitted]

Science Meeting Examines 'Phobos' Data

LD1402135889 Moscow TASS in English 1333 GMT 14 Feb 89

[Text] Moscow February 14 TASS—By TASS correspondent Vladimir Isachenkov: Data about the surface and atmosphere of Mars and near-Martian plasma obtained by the space probe Phobos-2 are being discussed at an international scientific conference which opened on Monday at the Soviet Academy of Sciences' Space Research Institute.

Scientists from over a dozen countries, who are taking part in the discussion on the Phobos project, will submit their proposals for the scientific equipment and basic elements of the next automatic expedition which will explore Mars from a satellite, balloon and miniature landing craft. Its launch is scheduled for 1994.

Two Phobos orbiters were launched from the Baykonur spaceport on July 7 and 12. Contact with the first of them was lost in September. The onboard systems of Phobos-2, which reached Martian orbit on January 29, operate normally. The sole hitch has been a drop in a radio transmitter current and, hence, a reduction in its capacity. This will not, however affect the implementation of the programme. The scientific equipment of both vehicles was virtually identical.

Academician Roald Sagdeyev, scientific director of the project, singled out two of an array of experiments conducted when the probes were flying from Earth to Mars. The first was to photograph solar corona in Roentgen range and the second—to explore solar radiation oscillations. Thanks to them, scientists received new data about the structure and dynamics of the sun's internal composition.

Research into the planet's surface and atmosphere has already been conducted in the near-Martian orbit with the aid of an infra-red spectrometer. Its results will enable specialists to draft height maps of separate areas of Mars and analyse the mineral composition of the rock. Scientists hope to spot carbonate deposits, which can indicate the previous existence of water. The measurements of the surface temperature showed that it is 20 degrees higher than was previously thought and even more in volcanic areas.

There are plans to film the planet shortly and also to observe the sun's spectrum through the Martian atmosphere. This will enable scientists to analyse its chemical composition. The Phobos mission will enter its decisive phase in April when following several manoeuvers; the space vehicle will approach the Martian moon at a distance of 50 meters and explore its soil by conventional television cameras for 25 minutes, and then by laser, ion and radar probing.

'Phobos' Placed in Observation Orbit 18 February

LD1802211988 Moscow TASS in English 2045 GMT 18 Feb 89

[Text] Moscow February 18 TASS—A TASS correspondent reports from the Flight Control Center:

The Phobos automatic station making a flight around Mars was transferred to a new orbit from which navigational measurements and observatons of a Martian satellite, Phobos, will be made.

At 17 hours 06 minutes Moscow time on February 18 an autonomous engine of the station was fired at the command from the onboard control complex. As a result of the maneuver the spacecraft was transferred to an orbit of observation around Mars close to a circular orbit with an average radius of 9,670 kilometres, the period of revolution of eight hours and the inclination of 0.5 degrees.

Upon concluding the maneuver the autonomous engine which had served its purpose was separated from the station at the command from the onboard control complex. Throughout the 220-day flight, the engine had been used for putting the station into an interplanetary trajectory, for making two corrections on the stretch of the flight on the Earth-Mars route, for the maneuver of putting the station into an orbit of an artificial Martian satellite and two subsequent maneuvers for shaping the orbit of observation of Phobos.

During the flight on the observation orbit, it is planned to conduct observation of Phobos by means to study its form and relief in detail and also to make navigational measurements to detemine the position with regard to a natural and an artificial satellites of Mars. The preliminary results of the measurements received were discussed at meetings of the International Scientific Council held at the Institute of Space Studies of the USSR Academy of Sciences. The incoming information is processed.

The station will remain in the observation orbit for about four weeks, after which maneuvers for rapprochement with Phobos will be made with the use of engines with small thrust.

Space Probe Transmits First Images of Mars Moon

LD2102211689 Moscow TASS in English 2103 GMT 21 Feb 89

[Text] Moscow February 21 TASS—TASS correspondent reports from Flight Control Center: The unmanned space probe "Phobos", which continues to circle Mars, has relayed to the earth the first images of its natural moon Phobos.

As was already reported, on February 18 the probe was transferred to a new observation orbit which is close to circular and has a radius exceeding by 300 kilometers the radius of Phobos' orbit. Exploration of the atmosphere of Mars, its surface and near-planet space continued from the observation orbit for three days.

The first television transmission session was held from 15:35 to 16:25 on February 21 when the spacecraft was at a distance of 860 to 1,130 kilometers from this celestial body. On commands from the probe's onboard controller, under the program developed in advance, the craft maneuvred for focussing on Phobos.

A high-quality image of Phobos from various angles was recorded on nine television sequences. Video information obtained during the session was transfered to the onboard storage and relayed to the Flight Control Center during a regular communication session, where it will be used to specify the parameters of the movement of Phobos and the spacecraft with a view of their subsequent rendezvous.

Phobos was recorded by television equipment developed jointly by specialists of the Soviet Union, the People's Republic of Bulgaria and the German Democratic Republic.

The next television session in the observation orbit is planned for February 23.

Deputy Flight Director Details 'Phobos' Achievements

LD2202183989 Moscow Domestic Service in Russian 0500 GMT 22 Feb 89

[Interview with "Phobos" deputy flight director Nikolay Sukhanov by unidentified correspondent; date, place not specified; recorded]

[Text] The "Phobos" interplanetary station has transmitted to earth television images of this moon of Mars. Our correspondent has interviewed Nikolay Georgiyevich Sukhanov, the spaceship's deputy flight director.

[Begin recording] [Sukhanov] It is pleasant to see what we have been aspiring to for more than 7 months now and toward which we will make further progress. These photographs were not really taken for their own sake, but in order to acccomplish navigational tasks. To be specific, our objective is to move as close to "Phobos" as possible, then to drift along its surface and release a long-term automatic station to "Phobos."

[Correspondent] Before this flight, after all, we did not have an accurate idea of the orbit of "Phobos," and the tolerances were very large, in the tens of kilometers.

[Sukhanov] Yes, and by the nature of these measurements we are taking of "Phobos" with the help of these television stills, we can define more precisely the positions of the spacecraft and "Phobos" relative to one another. I want to call attention to the fact that "Phobos" is at the center of the photographic still. All in all, this is self-evident for a photographer who is making a portrait of someone, but it was not at all self-evident for us. The fact that it is at the center of the still shows that our ballistic and navigational calculations proved to be fairly correct. Such accuracy allows us to make good plans for the further course of the operation, and in particular, we propose to conduct a session analogous to today's on 28 February, when the conditions will be better for observation, as the distance to "Phobos" will be approximately three times less. For this reason, we will see "Phobos" itself as considerably larger, and the precision we achieve will be approximately three times greater. In addition, these photographs are probably of great scientific significance. Planetologists will, of course, study these photographs.

[Correspondent] This is a powerful and emotional moment, but tell me, please: What could you compare it with?

[Sukhanov] Today is truly a joyful day and probably, in its emotion, it could be compared with the point at which a mountaineer climbs a mountain; perhaps he is not at the summit yet, but he knows that he is close. You somehow begin to feel that this job can be completed now.

[Correspondent] Could you be compared with a sailor who has been on a long, long journey and now has seen the shore? He does not know what it is, but he can see it already?

[Sukhanov] Yes, we have seen the shore we must sail to. We now can see where we must go and we will devote all our strength to traveling this last section of the way successfully. [end recording]

'Phobos' Scan Obtains Imagery of Martian Surface

PM2702144189 Moscow IZVESTIYA in Russian 26 Feb 89 Morning Edition p 1

[Article by Doctor of Technical Sciences A. Selivanov, head of department in the USSR Main Administration for the Creation and Utilization of Space Technology, and Candidate of Technical Sciences M. Narayeva, senior expert in the USSR Main Administration for the Creation and Utilization of Space Technology: "The Surface of Mars: Important Experiment"]

[Text] The implementation of the "Phobos" project is nearing an extremely important stage: The landing of automatic space vehicles on the natural satellite of Mars.

This operation was preceded by the process of gradually moving the interplanetary station into orbit; the station recently became an artificial satellite of the red planet and is to converge with "Phobos."

Not only "Phobos" but Mars itself remains a highly interesting subject of scientific research and great possibilities for this have now opened up.

However unique the research conducted during the study of any planet, as a rule this research seems incomplete if we cannot actually see a picture of the planet in question.

The surface of our neighbor, Mars, has been repeatedly photographed by television cameras from the Soviet and American interplanetary stations "Mars" and "Mariner." Good quality color images have been obtained, charts plotted, and the landing locations of the "Viking" space vehicles studied in detail.

This time a totally new experiment is being carried out: to obtain a highly detailed thermal chart of Mars which will make it possible to distinguish the temperature of individual formations on its surface—craters, valleys, crevices, and so forth. This job is being done by an instrument known as a thermoscan. Its closest (but less sophisticated) analog on earth is an infrared imager sensitive to thermal, infrared rays.

In the original plan, the work of the thermoscan was to begin in April in circular orbit, at an altitude of 6,000 km. This would allow details of approximately 2 km in size to be distinguished on the surface and give a field of vision of 600-700 km. But before moving into this orbit the "Phobos" station made several revolutions around Mars in an interim elliptical orbit with a minimum altitude of approximately 800 km. The natural desire of the people involved in the project was to take photographs at a distance considerably less than the nominal distance, which would proportionally increase the distinctness of small details on the surface—up to several hundred meters. This unique photograph was taken successfully on 11 February.

The course of the photograph ran a length of 8,000 km through the desert region of the Amazonka plain, in ill-defined relief. However, at the end of the sequence several large craters came within the field of vision of the thermoscan. One of them, with a diameter of approximately 30 km but no name at present, is printed on the photograph. The photograph itself is the result of preliminary processing of the heat photograph carried out by the Scientific Research Institute of Space Instrument-Making of the USSR Main Administration for the Creation and Utilization of Space Technology and the USSR Academy of Sciences Information Transmission Problems Institute. It should be pointed out, in particular, that the data relating to surface temperature cited at various points on the photograph is strictly preliminary data and has yet to be clarified during further processing. An important supplement to the heat photographs based on infrared rays invisible to the eye are the photographs taken in the visible spectrum. They are taken by the thermoscan simultaneously with the heat photographs and are used for comparative analysis.

On the whole, this 30-minute sequence has yielded a great deal of new and interesting information. The processing of this information will take some time.

This piece of Soviet equipment—the thermoscan—and the data it has produced effectively supplement the results of other equipment in the scientific complex of the "Phobos" station implemented with the participation of broad international cooperation.

'Phobos' Continues Study of Mars, Martian Moon

Movement of Moon Phobos Measured

LD0103024689 Moscow TASS in English 1954 GMT 28 Feb 89

[Text] Moscow February 28 TASS—The data obtained during Tuesday's [28 February] television session under the international project Phobos will be used by specialists further to specify the parameters of Martian Moon Phobos' movement. This session was necessary to get as much information as possible about the red planet's companion, a TASS correspondent has learnt in the Flight Control Center.

Without this it is impossible to pass over to the next responsible stage of the project—propelling the Soviet unmanned interplanetary probe Phobos from the so-called orbit of observations, in which it is placed now, to the orbit which is synchronous with Phobos.

When the first session to beam broadcasting images of Phobos was held a week ago, the spacecraft was at a distance of 860 to 1,130 kilometers from the moon. During Tuesday's session this distance has significantly shrunk. The broadcasting was done at a distance of 320 to 440 kilometres. Eventually, it is planned to transmit television pictures of Phobos' surface already from the so-called quasi-satellite orbit at a distance of 100 kilometers. Specialists are waiting with impatience for an important event—the dropping of a landing craft on Phobos.

The Phobos probe was launched from the Soviet Baykonur Space Port on July 12, 1988. During this time specialists explored the sun and interplanetary space. The project involves specialists from ten countries and also the European Space Agency.

Tests Measure Solar Wind, Temperatures

LD0103203889 Moscow TASS in English 1956 GMT 1 Mar 89

[Text] Moscow March 1 TASS—By TASS special correspondent reporting from the Mission Control Center:

The Soviet unmanned space probe "Phobos", orbiting round one of Mars's two satellites, conducted another series of scientific studies Wednesday [1 March].

At 10:00 a.m. Moscow time, the station switched on instruments of a plasma complex intended for obtaining information on the solar wind flowing around Mars and characteristics of the planet's magnetosphere.

At 4:22 p.m., the onboard control complex issued the command to start taking pictures of Mars in infra-red rays.

High-quality thermal images of the planet were obtained with the help of the Termoskan instrument. The images make it possible to distinguish, with high accuracy, temperatures on different parts of the relief.

The new photos, as well as those transmitted by the probe on February 1, will be used for making thermal maps of Mars.

Instruments intended for studying the elemental and isotopic composition of Phobos's surface were tested with the view to preparing them for forthcoming studies.

The scientific information received from the probe is being processed and studied.

'Phobos' Mission Continues Experiments

LD1503211289 Moscow TASS in English 2103 GMT 15 Mar 89

[Text] Moscow March 15 TASS—TASS correspondent reports from Flight Control Center:

The Phobos automatic probe continues its flight around Mars. Between March 7 and 14 the space station performed investigations of solar oscillations, x-ray and ultraviolet radiations emitted by the sun, space rays and space and solar gamma-splashes. The probe continued studying the planet's surface and making measures of magnetic fields and characteristics of space plasma.

The control group specified the parameters of the spacecraft's orbit after a maneuver performed on March 7. Another orbital correction was made with small thrust engines of the station at 17:20, Moscow time, on March 15 to form optimum synchronous orbit which will bring it closer to Phobos.

According to trajectory measurings made by Soviet ground posts in Yevpatoriya and Ussuriysk, the operation with the Martian man-made satellite which is 250 million kilometers away from the earth, was carried out successfully.

'Phobos' Probe Moved Into Synchronous Orbit

LD2203043489 Moscow TASS in English 2345 GMT 21 Mar 89

[Text] Moscow March 22 TASS—Upon the completion of the next stage in scientific research and specifying the parameters of the orbit formed on March 15, the unmanned interplanetary probe Phobos was switched to the first synchronous orbit which ensures up to 200 kilometres of periodic movement with Martian moon Phobos and the same period of revolution around the planet, says a report from the Mission Control Center.

To execute this maneuver, the space orbiter made several turns on command from the on-board computer and, under the program developed in advance, took the necessary position in space. Small traction engines were fired at 17:46 Moscow time [1446 GMT] on March 21 and the station was propelled into an orbit which is synchronous with Phobos' orbit.

The accuracy of the knowledge of the probe and Phobos' relative position within the ten-kilometer limits has been achieved by now. To ensure the dropping of autonomous landing craft on Phobos' surface, the required accuracy of the knowledge of the relative position should be one to two kilometers. Trajectory measurements and television pictures of Phobos will be made to accomplish this task and also choose the area of landing during the flight along the synchronous orbit.

Once the information processing results are achieved, maneuvers will be made to transfer the probe to the second synchronous orbit, ensuring its further movement toward Phobos.

Progress of 'Phobos' Spacecraft Reported

LD2503173589 Moscow TASS in English 1717 GMT 25 Mar 89

[Text] Moscow March 25 TASS—TASS special correspondent reports from the Flight Control Center:

The Phobos space station continues its mission around Mars. During the travel along the first synchronous orbit on March 22 and 23, the spacecraft continued investigating processes on the sun and in the near-planet space, registered magnetic fields and splashes of gamma-radiation of various origin.

A session of natural Phobos's TV filming was held on Saturday between 12:20 and 13:40, Moscow time [between 0920 and 1040 GMT], when the spacecraft was at a distance of between 279 and 191 kilometres from the Martian satellite. The snapshots give a chance to specify a relative position of the craft and Phobos and to get additional information to pinpoint a place for landing independent probes on the satellite. Under the flight program, it is planned to photograph Mars again in infrared rays on March 26.

Now the Flight Control Center and the Space Research Institute of the USSR Academy of Sciences are processing information transmitted by the Phobos station and analysing data of ballistic measurements to prepare for a switchover to the second synchronous orbit.

'Phobos' Probe Photographs Mars, Martian Moon

LD2703173689 Moscow TASS in English 1720 GMT 27 Mar 89

[Text] Moscow March 27 TASS—The Soviet space probe "Phobos", orbiting around Mars, continues monitoring the planet and its satellite Phobos, the Mission Control Center reported Monday.

On Sunday [26 March], "Phobos" did television and thermal filming of Mars, obtaining high quality images of the planet's surface in the optical and infra-red bands.

In accordance with the flight program, the station's television cameras filmed Phobos tonight to more accurately specify the spacecraft's location relative to the satellite.

Stable Radio Contact With 'Phobos' Probe Lost

LD2803175189 Moscow TASS in English 1640 GMT 28 Mar 89

[Text] Moscow March 28 TASS—By a TASS correspondent at the Mission Control Center:

In keeping with the mission's program, further operations involving the space probe Phobos were conducted on March 27. On commands from the on-board control system, the craft was turned to automatically take pictures of the Martian moon Phobos.

After these operations were completed, the information was to be sent back to earth. But mission control was unable to establish stable radio contact with the probe as scheduled.

The possible causes of the loss of contact are being analyzed and efforts are continuing to regain it.

Commission To Investigate Loss of Radio Contact With 'Phobos-2'

LD2903160689 Moscow TASS in English 1544 GMT 29 Mar 89

[Text] Moscow March 29 TASS—An expert commission has been given a week to find out why radio contact has been lost with the unmanned space probe Phobos-2, according to the chief of the Soviet Space Agency Glavkosmos, Aleksandr Dunayev.

He told the daily IZVESTIYA that efforts to restore links with the craft are contining round the clock and the possible causes of the breakdown are being analysed.

Following the experts' recommendations, a plan of further action will be adopted and "we all hope for a favourable outcome", Dunayev said.

IZVESTIYA, reporting from the Mission Control Center, said that the space probe was turned on March 27 to take television pictures of the Martian moon Phobos in order to specify the parameters of its orbit.

After the operations were completed, the information was to be beamed back to earth but mission control failed to establish regular contact with Phobos-2 despite repeated attempts.

'Phobos-2' Communication Problem Described

LD0404141989 Moscow World Service in English 1110 GMT 4 Apr 89

[Text] The Soviet Space Mission Control Center says the radio link with the unmanned interplanetary space probe "Phobos," currently orbiting Mars, has so far failed to be restored. Our reporter has asked a space mission control official, (Yuriy Kolesnikov), to explain what has happened to the probe.

For several weeks, he said, the Mission Control Center received unique information. After many months of flight the probe had entered into orbit around Mars and then closed up with its natural satellite. On commands from the earth the probe changed several orbits to approach Phobos. However, when a mere several hundred kilometers remained between the probe and the

station, communication was frustrated. That happened on Monday, 27th March. The probe's radio transmitter, which under the program had remained silent during a photography session, was expected to switch on at 1859 but failed to do so. The control team urgently issued additional orders which seemed to have worked. At 2050 the space probe responded; however, radio communication lasted for a mere 13 minutes. All subsequent attempts to re-establish contact with the "Phobos" probe failed.

What has happened to the spacecraft? Experts have taken intensive measures in a bid to find the causes of the breakdown. Twelve teams of designers, scientists, engineers, and experts in ballistics have around the clock been analyzing the performance of various systems of the space probe and the situation in general to present recommendations to the control team. True, in a situation like this chances for success are controversial. Besides, the "Phobos" probe currently orbiting Mars disappears in the shade of Mars and the Sun for one and a half hours three times a day and is beyond the reach of radio transmitters. Besides, the great distance between the earth and the probe poses additional difficulties. It takes a radio message about 15 minutes to reach the probe. The answer travels as long. Yet the control team still have hope, said (Yuriy Kolesnikov).

'Phobos' Mission Described, Spending Questioned

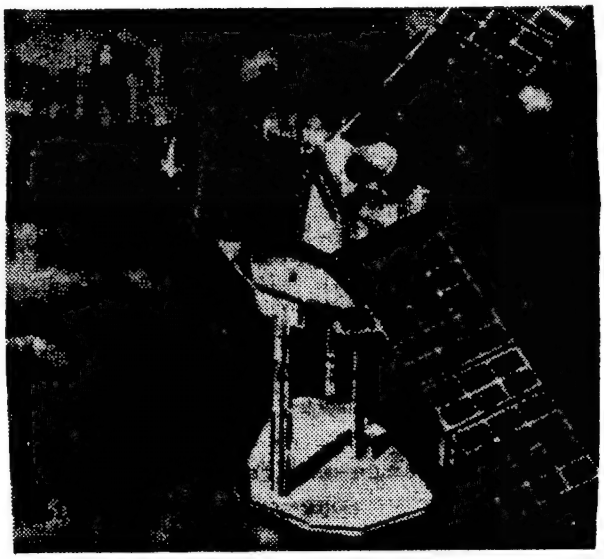
18200289 Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 26 Mar 89 pp 1, 4

[Article by G. Lomanov: "Project 'Phobos,' or the Blitz-Tournament With an Unknown Adversary"]

[Text] Project "Phobos" is coming closer and closer to its culmination moment. In the first 10 days of April, the Soviet interplanetary station will make a low-level pass over the Martian satellite and will drop a permanent station on it with a set of unique scientific instruments and an automatic probe which scientists have named "the frog"—after touching the surface, it will stretch out its little mechanical legs and make several 20-meter hops, changing its place of exploration.

Before recounting the objective and methods of the unusual experiment, it is necessary, perhaps, to make a short but important digression. The editorial office receives mail almost every day with the questions: Why is the cost of space exploration kept secret? Do we need expensive programs when store shelves are by no means abundantly supplied, and when at times you do not know what to feed the baby? The questions are pointed, they are by no means idle, and they have to be answered. Thus, at least the cost of the "Phobos" project is not a secret. I look through my notes in my notebook, which I made before the launch of the interplanetary station. V. Balebanov, deputy director of the Institute of Space Research of the USSR Academy of Sciences, reported that the cost of the development and manufacture of scientific equipment was somewhere in the neighborhood of R40 million. The question concerned our expenditures, inasmuch as 14 countries and the European Space Agency participated in the "Phobos" project—our foreign partners contributed about the same amount in dollars. After adding up the cost of the launch of the "Proton" rocket, the stations themselves, and also a number of other expenditures, we arrive at a sum that is almost R300 million. It should be noted that a part of the means was used for the creation of terrestrial experimental devices and the command-measuring system devices that are intended for multiple operations.

One station was lost as a result either of error or operator negligence. It is a pity, but nothing can be done about it now. The second successfully avoided the reefs and shoals of outer space and is now heading for a rendezvous with Phobos. Why was it that precisely this Martian satellite was chosen as an object for exploration? Rephrasing the question, for what reason was such a long voyage undertaken? Recently, the attention of researchers has been drawn more and more to the small bodies of the solar system—comets, asteroids, and planetary satellites, Phobos among them. These relic objects are witnesses to the very early stages of the formation of our planetary system. They were formed long before the most ancient terrestrial rocks, and their study, possibly, will help to fill in the "blank spots" in the history of the universe.



Autonomous station on surface of Phobos

To begin with, whether the purpose justifies the expended resources will very likely have to be judged by the specialists. And, nonetheless...when thinking about this question, one automatically recalls the caustic aphorism of Academician L. Artsimovich: Science is a method for satisifying personal curiosity at the state's expense. It is hardly reasonable to call for curtailing space programs, but it is more than reasonable to give it

some thought, as is done by our readers: Where is it better to spend these hundreds of millions? On prestigious projects or on the construction and establishment of homes for invalids and old people?

However, it is time to move from thinking about economic problems to scientific matters. Thus, Phobos. As far back as the beginning of the 17th century, I. Kepler stated the proposition that Mars has a satellite. But scientific forecasts are not a remarkable thing for us—to this day there is nothing that excites people more than the prediction of the famous English satirist J. Swift. A century and a half before the discovery of Mars' satellites, he named the periods of their revolution around the planet. What is this—a coincidence, something that dawned on him? I am afraid that we will never know the answer. But the American astronomer A. Hall saw the satellites of the Red Planet in a telescope for the first time during the great opposition of Mars in 1877. And he called them Phobos and Deimos, which means "fear" and "terror."

At the beginning of the sixties, an eccentric hypothesis of Soviet astrophysicist I. Tsiolkobskiy roamed the pages of scientific and the more popular publications. He proposed that Phobos...is an artificial heavenly body. It would seem that this is a fantasy of the first water. Not entirely—there were reasons for such a version. Astronomers noted that, revolving around the planet, the mysterious satellite was gradually getting closer to it. Perhaps the Martian atmosphere was acting like a brake on it? If so, given quite respectable dimensions, Phobos should have a small mass, and this could mean that it was hollow inside. Nature does not tolerate such an emptiness, which means that Phobos is not a natural satellite, but was created by an unknown civilization.

Alas, this hypothesis with enticing secrets had to be shelved in the archives. At first, the American satellite "Mariner-9" and, later, "Viking," transmitted images of the red planet's satellite. The photos, and one could distinguish details in them on the order of meters, left no room for doubt that Phobos was a natural satellite of Mars.

However, even now information on the mass, internal structure, and even moreso the composition of the rocks, would hardly be called 100-percent reliable by anyone. There is an old rule—the more scientists learn about a research topic, the more new questions arise. Here is an example—long strips are quite noticeable on the photos. As if a giant unknown wild beast scratched the surface with its claws. What is this? One of the suppositions is that they are fissures from the impact of a large meteorite, which was afterwards filled with a crumbly substance—regolith.

One can still wander for a long time in the labyrinth of various, and at times mutually exclusive, models and hypotheses. Information obtained from the "Phobos" station can become a real Ariadne thread for scientists [in Greek mythology, thread used to get out of a labyrinth]. The research program provides for the study of plasma, solar winds, cosmic rays, X-ray, and ultraviolet radiation of our luminary. But the main objective is the study of the Mars satellite. More than 20 instruments are on board the interplanetary station, and more than half of them are earmarked for exploring Phobos.

Plan for landing long-term autonomous lander and hopper probe

It is interesting to compare some figures. The flight to the vicinity of Mars took 200 days. Another two and a half months was taken up by maneuvers in an orbit around the planet. And only 15-20 minutes will be devoted to exploring Phobos itself from onboard the station. The fact is that it is impossible to place the station in orbit around the Martian satellite—Phobos's mass is too small, its gravitational force is minimal, and a heavy interplanetary apparatus cannot be kept on such a "little string." Only one thing can be done—after making coincident the orbits of the natural and manmade satellites that are revolving synchronously around Mars, accurately bring "Phobos" to Phobos.

The space laboratory is well-equipped. For example, with the help of the thermoscan instrument, scientists hope to obtain a detailed thermal map of Phobos. Television equipment will provide colored images of the surface, on which it will be possible to distinguish details the size of several centimeters, and not meters, as on the "Viking" photos.

One of the most interesting and important experiments will be conducted with the aid of the remotely operated laser mass-analyzer LIMA-D. The instrument was developed by specialists of the Leningrad Institute of Precision Mechanics and Optics in collaboration with scientists from the GDR, Bulgaria, Finland and Czechoslovakia. The penetration of the laser ray will cause a very small explosion in a rock and a vapor cloud

of the matter—ionized gas—will be entrapped while rising. Then the instruments will conduct an analysis of its physico-chemical properties.

And all in all this takes just a little more than a quarter of an hour. The equipment will work under extremely strenuous conditions. Here, as if in a blitz chess tournament, any error means losing the game. And this extremely complicated experiment is conducted in an automatic routine millions of kilometers from earth, when it takes the radio signal more than 10 minutes in one direction. There is no way to interrupt, correct, or repeat. One can only hope that everything that was intended turns out all right.

Efforts to Salvage 'Phobos' Mission Viewed

PM0604103989 Moscow KRASNAYA ZVEZDA in Russian 4 Apr 89 First Edition p 3

[Lieutenant Colonel V. Baberdin report: "The Riddles of the Martian Orbits"]

[Text] What has happened to the "Phobos" probe? Is there any hope that communications with it can be restored, that it will again fulfill commands from the earth and continue the exploration of the mysterious planet and its satellite? We have received many questions of this kind from the newspaper's readers lately. Our correspondent reports from the Mission Control Center.

I am looking at a diagram depicting the flight path of the automatic interplanetary probe, which is lying on a desk in one of the offices at the Mission Control Center. In the middle, Mars is pictured in red. And here is the orbit of Phobos, the "red planet's" natural satellite. Slightly to the side and 371 km further out is the orbit of the man-made satellite. And all this is happening some 270 million km away.

We have reported how, initially, the space apparatus was placed in a provisional elliptical orbit around Mars, which was later corrected to become circular. Readers will remember how remote-control photographs were taken of Phobos and how a survey of the surface of the "red planet" was begun. The equipment and instruments were functioning normally, specialists at the Mission Control Center were pleased with the quality of the photographs received from space. Many of them were unique. For instance, those taken with the help of the "Termoskan" [thermal scanning] instrument in the infra-red electromagnetic wave range. They enabled us to obtain an accurate, high-resolution picture of heat emanations on the surface of the Mars. No one had done this before.

Then came the most complex and crucial stage of the expedition — maximum approach to Phobos and depositing of instruments on its surface. A date for carrying out this operation had already been set. It was then that the unexpected happened. On 27 March the automatic interplanetary station failed to resume communications with the Mission Control Center. This is how it happened.

The first daytime communications session lasted from 1125 through 1347 Moscow time. There were no problems. The operators were receiving telemetric information promptly from the spacecraft, feeding data into the onboard memory, and making radio checks of the orbit.

The next communications session began at 1559. Operations similar to those carried out on 25 March were planned—television filming of Phobos from a distance of 214-371 km and transmission of the image to the earth. The aim was to obtain information needed to gain a more accurate picture of the mutual positions of the probe and of Phobos itself, so as to set a time for the approach and select a site on the surface which could be safely overflown at an altitude of 50 meters. All this is done automatically in accordance with commands fed by Mission Control operators into the station's onboard control system in advance.

At the scheduled time when the filming of the Mars satellite began, the onboard transmitter was switched off and communications with the earth were suspended as planned. They were to resume when the filming was finished.

1859...1905...the "Phobos" probe remains silent. The Mission Control Center control group swiftly analyzes the situation and takes prompt action to restore communications with the space probe....

2050...Mission Control picks up a signal from "Phobos," but after 13 minutes it disappears again....

To date communications with the probe have not been reestablished, although it is obviously still in orbit and its equipment and systems are functioning. What has happened? There are many hypotheses. It cannot be ruled out that for some reason, for instance as a result of being hit by a meteorite (whole showers of them are observed in the vicinity of Mars), the station has been disoriented and is spinning. Mission Control specialists have worked out a number of options for restoring communications. However, there are many complications. It takes 30 minutes for a signal to reach the probe and return to earth. Furthermore, three times a day the "Phobos" probe is in the sun's shadow or in the radio shadow of Mars for up to 90 minutes at a time.

To analyze the situation in depth and examine the problems comprehensively, 12 special groups of engineers and scientists have been set up. They are drawing up recommendations and daily programs for the Mission Control group.

And now about the mysterious patch on the photograph of the Martian surface taken in the infra-red wave range, which was mentioned during one of the reportages on Central Television's "Vremya" program. It is now being carefully studied by astrophysicists and planetologists. Most probably it is the shadow of some space object (which can produce a sharp drop in temperature on the surface of the "red planet" like the one picked up by the probe's heat spectrometer). However, as to what object it is (the probe itself, or a natural satellite of Mars) is not yet clear. However, it is not very likely that this shadow is in any way connected with the loss of communications. That is the specialists' opinion as of now. Work is continuing at Mission Control Center.

'Phobos' Project Discussed at Gagarin Forum

LD1004203189 Moscow Television Service in Russian 1700 GMT 10 Apr 89

[From the "Vremya" newscast; unidentified correspondent's video report]

[Text] [Announcer] The traditional Gagarin Readings opened in Moscow today.

[Unidentified correspondent] They have started, but not finished. Such has not often happened in recent years. This forum usually brings together the leaders of design offices, works and institutes, scientists involved in the mastery and study of space. Many of them have lived for long years under the seal of secrecy, and indeed their reports, with rare exceptions, resembled press reviews on cosmonautics. Much was said about successes, while the blood and sweat of those people stayed out of the discussion. Today the situation has changed dramatically. The diagrams and facts showed the colossal difficulties which cosmonautics must solve.

(Gleb Yevgeniyevich Lozino-Lozinskiy) the leader of the Molniya Scientific Production Association, has every reason to be proud of the Buran tests, but in his report the main thing is that Buran provided the method for developing designs which should be transferred to all of the country's machine-building. The amount of orders to the scientific production organization for automation of work in various sectors of industry runs into hundreds of millions of rubles.

Roald Zinnurovich Sagdeyev spoke with enormous sadness about the disorganization and hard interrelations of internal coordination at the early stage of the "Phobos project." Incidentally, today at the readings, all those present learned from the scientists that the second "Phobos" has been lost, like the first one. In a nutshell, the discussion did not end, but the main thing now is that there is not yet a single approved outer space research program, and this will unfailingly lead to lagging behind the world level of research. [video shows Sagdeyev addressing conference, other scenes from conference, including pictures of Buran]

[Begin video interview] [Academician V.S. Avduyevskiy] (?In connection with) the sharp discussions which there have been in the press and in the speeches of the people standing as MPs [members of parliament] on matters of spending on space, we decided to hold this year an interim session of our Gargarin readings, in order to discuss all these problems. In connection with the "Phobos" failure, this unusual sort of session came about. Space must get its set budget and it must be utilized to the best effect in order not to damage scientific research or the national economy, and, most importantly, our country's technical level must not fall, but on the contrary, rise.

[Correspondent] But it seems to me that at one time we were so over secretive that now we are starting to reap the fruits of that superfluous secrecy which used to prevail.

[Avduyevskiy] Understand that if I am to give my personal viewpoint, then I consider that in general there should be no secret scientific works. Fundamental work should all be open in general, fundamental scientific research. As for applied methodological work, technological work, work on creating new materials, they have the right to be closed from commercial considerations, but, say, not more than 1 or 2 years, or 3 years at the maximum if it is connected with the country's security. Our main shortcoming, of course, was the fact that within the country we made artificial barriers. There is still a price; if all the budgets are published, we shall see that this price, the price of space research will drown in the budgets of other recklessly spent money. [video shows interview in foyer] [end video interview]

Efforts to Contact 'Phobos-2' Craft Discontinued

LD1504202689 Moscow TASS International Service in Russian 1425 GMT 15 Apr 89

[Text] Moscow 15 April (TASS)—The commission that analyzed the causes of the loss of communication with the "Phobos-2" space vehicle has decided to discontinue the attempts to establish contact with it. This was reported by Roald Kremnev, chief designer of the Research and Test Center imeni G. Babakin, at a news conference held on Saturday at the Mission Control Center in the Moscow area.

Communication with "Phobos-2" was lost on March 27. "After a telephotography session 'Phobos-2' did not make contact with the earth. After 4 hours of attempts to establish communication a weak response signal was received, but quickly disappeared," Kremnev said. "Judging by the parameters of the signal, 'Phobos-2' lost its bearings and is rotating. Its solar batteries stopped supplying energy, while the capacity of electric batteries is enough for only 5 hours of work. Further attempts to establish communication were futile. By 13 April the temperature on board the space vehicle went down to a critical point under which on-board instruments could not function. This is why it was decided to discontinue the attempts to establish communication with the space vehicle."

According to Kremnev, at present no one knows for sure which of the systems failed. Perhaps, it was brought about by some outside factor, for example, a flash of static electricity or a mechanical impact on the space vehicle.

Analysis of the telemetry information received is continuing. "In any case it is clear that it wasn't a 'Martian missile' as a commentator on Soviet television jokingly suggested, that was responsible for the loss of 'Phobos'," Professor Arnold Selivanov, designer-in-chief of the radio complex, assured the journalists. "A mysterious disc-shaped shadow is visible in a photo of the surface of Mars received by the 'Termoskan' apparatus. However, this is not the trace of a missile taking off, but a shadow of a natural satellite of Mars. It is not round, but spindle-shaped, because the 'Termoskan' works in the infrared rather than the visible spectrum. This apparatus, which was being used for heat mapping of Mars, was being used in planetary research for the first time, and it has a great future."

As is known communication with "Phobos-1" was lost last September because an erroneous order was beamed to it. Yuriy Koptev, a representative of the Ministry of General Machine-building said that the cost of the two space vehicles, together with the expenses in preparing and launching them and also for flight control was R51 million. The total cost of the work on the program is estimated at R272 million. This includes spending on experimental design work, the perfection of 70-meter telescopes in Yevpatoriya and Ussuriysk, and the creation of test benches. The expenditures of 12 other countries which took part in the creation of scientific equipment installed on board the "Phobos" space vehicles were estimated by Academician Roald Sagdeyev as 60 million foreign-currency rubles. He added that important scientific data had been obtained during the flight to Mars and on the near-Mars orbit.

According to Vyacheslav Kovtunenko, director general of the Lavochkin Research and Production Association, "Phobos" space vehicles should serve as a basis for planetary studies for the coming 15 to 20 years. New control systems and a radio complex which, apart from the reception and transmission of information, makes trajectory measurements with an accuracy of about 20 meters and 1-2 mm per second functioned normally during ballistic maneuvering in the course of the approach with "Phobos," at a distance of 250-270 million km away from the earth. "We set ourselves a complex engineering task: to close in on a Mars satellite which measures only 27 km in diameter. This demanded highly accurate ballistic maneuvers on the transitional orbits," Kovtunenko noted. The flight showed the effectiveness of engineering solutions used in the "Phobos" space vehicles. However, the combination of computer complexes controlling both the service systems and research equipment proved to be wrong. They should be isolated one from another which will increase their reliability. It is necessary to increase the capacity of on-board electric storage batteries. When these changes are made, the "Phobos" can be used as a basis for future projects.

UDC 523.4

Structure of Venusian Atmosphere Determined From Optical Measurements Made on 'Venera-11,' 'Venera-13' and 'Venera-14' Spacecraft

18660087 Moscow ASTRONOMICHESKIY VESTNIK in Russian Vol 22 No 3, Jul-Sep 88 (manuscript received 21 Oct 86, after revision 25 Oct 87) pp 262-271

[Article by Zh. M. Dlugach, Main Astronomical Observatory, Ukrainian Academy of Sciences]

[Abstract] Data obtained with spectrometers on the "Venera-11," "Venera-13" and "Venera-14" spacecraft and data in the literature were used for determining the optical parameters of the Venusian atmosphere on the descent trajectory, their change with time and comparison with results obtained earlier. A rigorous method for computing the radiation field in multilayer media described by Zh. M. Dlugach, et al. in ASTROFIZIKA, Vol 23, No 2, pp 337-348, 1985 was used; this method involves solution of the direct problem, with computation of a large number of models. The interpretation of spectrophotometric measurements is thoroughly discussed. The data in Table 1 indicate a considerable variability of the optical characteristics of the Venusian atmosphere with respect to optical density and the atmospheric content of absorbing substances for the spectral interval 0.45-1.01μm. Table 2 gives the computed spherical albedo of Venus and the corresponding values from surface observations. The use of the rigorous theory of radiation transfer for interpreting measurements made with the three vehicles gave approximately the same picture of atmospheric structure as the approximate methods used earlier. The actual values of atmospheric optical parameters, however, were somewhat different. Figures 4; references 24: 18 Russian, 6 Western.

UDC 535.24:523.42

Results of Research on Temperature Regime of Venusian Polar and Near-Polar Atmosphere by Radio Probing Method

18660053a Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 5, Sep-Oct 88 (manuscript received 25 Sep 87) pp 762-769

[Article by O. I. Yakovlev, S. S. Matyugov and V. N. Gubenko]

[Abstract] The results of atmospheric research in 42 polar and near-polar regions of Venus by the radio probing method from "Venera-15" and "Venera-16" are presented. The latitude relationships found among tropopause altitude, depth of temperature inversions, temperature at the level 1 bar and tropopause temperature are compared with the results obtained by the Pioneer-Venus satellite. The stability of polar atmosphere structure during the 5-year period separating the two series of measurements is noted. The contrasts of atmospheric temperature in the polar and near-polar regions are discussed, and contrasts of atmospheric temperature between the northern and southern

hemispheres are examined. A temperature asymmetry of the atmosphere in the northern and southern hemispheres in the polar regions is evident. Since the conditions for solar heating of the atmosphere by the sun in these hemispheres are virtually identical, the sole reason for the different temperature regimes of the hemispheres must be nonuniformity in the distribution of aerosol particles in the cloud and supracloud atmosphere of the different hemispheres due to volcanic eruptions on Venus. It is possible that the polar atmosphere is most sensitive to volcanic eruptions. The products of volcanic activity can attain cloud and supracloud altitudes only in these regions. The temperature contrasts in the two polar regions are possibly an indirect indication of a difference in volcanic activity in different hemispheres of the planet. Figures 7; references 11: 5 Russian, 6 Western.

5303

UDC 523.42-853.6

Magnetic Fields in Venusian Ionosphere
18660053b Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 5, Sep-Oct 88 (manuscript received 19 Mar 87) pp 770-784

[Article by A. M. Krymskiy and T. K. Breus]

[Abstract] The article gives a qualitative analysis of the nonstationary convection of plasma and the magnetic field in the Venusian daytime ionosphere and presents a comparison of different hypotheses on the formation and evolution of the large-scale field and "plaits" of magnetic lines of force in the ionosphere on the basis of the pattern of plasma convection. In part 1 of the article, it is shown that the earlier predicted latitudinally directed current sheet in the Venusian ionosphere, caused by the finite conductivity of plasma, is in fact absent. The observed large-scale field or magnetic belt is a result of evolution of the magnetic field of the solar wind driven deep into the ionosphere. The formation of the upper boundary of the magnetic belt occurs in the neighborhood of the upper boundary of the region of photochemical equilibrium in the Venusian ionosphere, where the characteristic velocity of the vertical convection of plasma is on the order of the velocity acquired by a particle during free falling in the planetary gravity field during the time of ionic-atomic collisions. Part 2 examines the mechanisms of formation and the evolution of the magnetic plaits. The existence of an ascending plasma flow in the upper ionosphere in the absence of a large-scale magnetic field and the stability of the ionopause relative to long-wave disturbances suggest that the destruction of the ionopause in the case of small dynamic pressures of the solar wind cannot be a source of the plaits of magnetic lines of force deep in the ionosphere. At low altitudes the magnetic plaits are formed as a result of destruction of the large-scale magnetic field driven into the ionosphere earlier. Figures 3; references 24: 6 Russian, 18 Western.

Buran and the Future of the Soviet Space Program

18660146 Moscow ZEMLYA I VSELENNAYA in Russian No 2, Mar-Apr 89 pp 3-10

[Article by USSR Academy of Sciences Corresponding Member Yu. P. Semenov, Doctor of Technical Sciences V. A. Timchenko, and S. K. Gromov: "Buran and the Future of the Soviet Space Program"; first paragraph is source introduction]

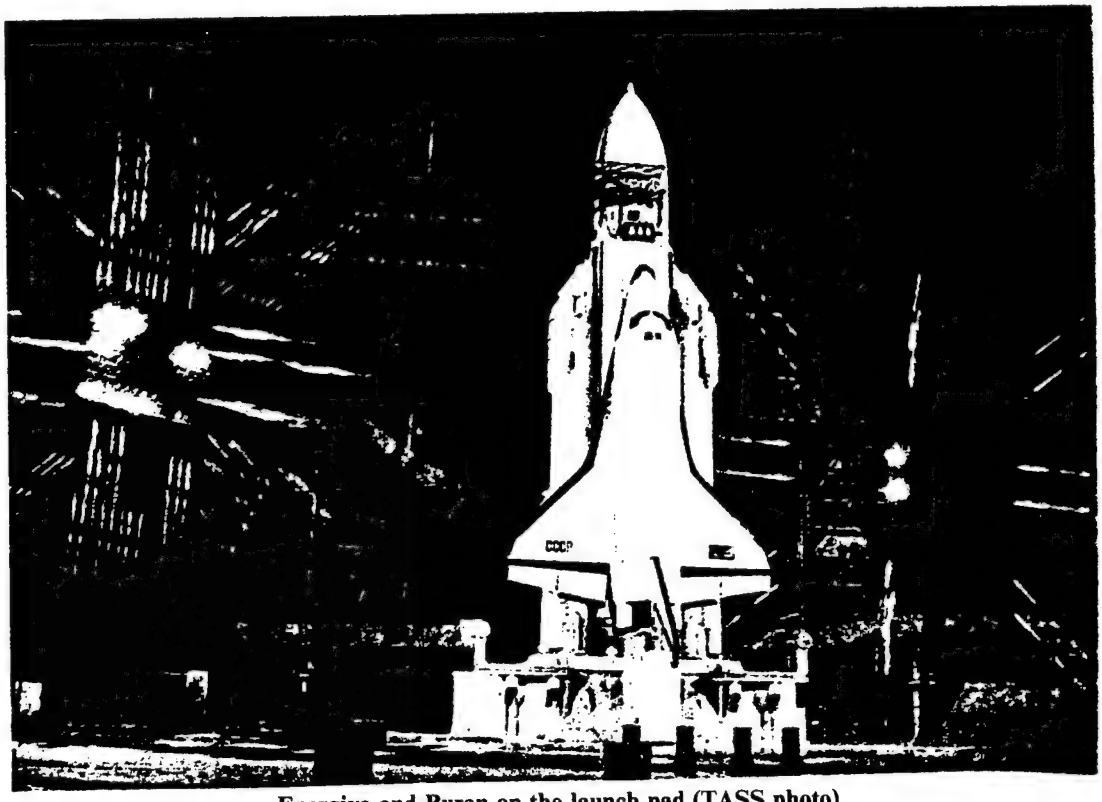
[Text] **On 15 November 1988, the versatile Energiya rocket-and-space transport system was successfully launched, and it placed the Buran reusable orbital craft into orbit. A new important stage in the development of the Soviet space program began with that flight.**

The successful launch of the new Soviet orbital craft Buran was the result of prolonged and multifaceted work by hundreds of teams of developers, designers, testers, builders, and specialists in many other professions. It would be difficult in one article to just list the whole multitude of problems they encountered in the course of the design, creation, and experimental testing of the reusable craft. The story of each of the individual aspects of the design is the topic of special publications, some of which are already in print, others of which are in press.

In addition to this, there are a number of general questions that will crop up with the reader, questions for which he may not at the moment have a specific answer. What moved the developers to pursue such a project? How did Buran's appearance become such as it is? Are reusable rocket-and-space systems always needed? How does the Soviet Buran differ from the American shuttle? What are the plans for Buran?

The systematic expansion of the work man does in space requires that the solutions that are adopted and the development of the methodological aspects of design and testing be clearly well-grounded. With space technology, every new step in its development is accompanied by the need to solve interrelated problems at the leading edge of very different fields of knowledge: flight and control dynamics, electronics, material strengths, materials science, testing technologies, mathematics, medicine, and many others.

In the course of a research effort based on the achievements of science and technology, the complex of problems that determine the features of the project and the appearance of the new craft is being solved. In this article, we wish to discuss some of the features that are specific to the development of the Buran craft.



Energiya and Buran on the launch pad (TASS photo)

More Than Just A Transport System

Perhaps we still can't think of booster rockets and space vehicles as means of transportation that are as versatile

as, for example, the automobile or the tram, with their immense tonnage and storage capacity. Spacecraft are vehicles that transport special equipment and professionally trained individuals—cosmonauts—and whatever is needed for keeping them alive and safe. More than a quarter of a century has passed since the first flight of man in space, but the payload capacity of manned craft has changed little. Embarking on long-term orbital flights, Soviet cosmonauts have very limited opportunities for the delivery of cargoes to the orbital complexes along the way. The problem becomes even more acute when it comes to returning cargoes from orbit. The Progress freighters don't solve the problem completely—they deliver needed cargoes and fuel to the station in automated mode, without cosmonauts, but they are not equipped with systems for returning cargoes from orbit to Earth. In other words, cargo craft efficiently handle tasks associated with supplying orbital scientific complexes with expendable elements and individual components of new equipment, whereas manned craft can perform any such functions, but only by cutting down the number of crew members.

In the past, the Soyuz craft were used for independent flights; but limitations in functional potential and in the weight of the cargo that could be transported led rather rapidly to the exhaustion of the range of tasks that could be handled by those craft without interaction or docking with other space facilities. The goals of today's space program, not to mention those of the future, call for near-Earth orbit assembly and servicing of complex, large space structures; of high-tonnage interplanetary manned vehicles; of unique scientific instruments; and of experimental installations. On the agenda are a transition to the industrialization of space and the beginning of the industrial use of the unique conditions of space for the purpose of, for example, producing various materials and substances with unusual properties. All this presumes the need to transport large cargoes into orbit and to perform operations in which vehicles must draw near to space facilities or dock with them.

Such tasks cannot be handled without skilled cosmonauts at the work site, equipped with a powerful arsenal of auxiliary equipment: robotic complexes, remote control devices, and all-purpose portable and nonportable instruments. Many types of work require going out into open space and performing vigorous labor there, and this means that spacesuits, air lock compartments and systems, and gear for securing things in the compartments and for moving the cosmonauts about in open space are needed. Docking assemblies and radio and optical equipment for making interrelated measurements are also needed for approach and docking.

The entire complex of the enumerated equipment can, to a large extent, be all-purpose and can be used repeatedly. Its preventative maintenance and routine inspection and repair can be done between flights. Since the weight of this entire complex, together with the crew and its life-support gear, is several tons, and the weight of the cargoes needed for doing work in space is even greater, the need to create a manned craft of a heavier class than, say, Soyuz becomes quite apparent. A manned vehicle well-equipped with various gear would open the door to its being used as a complex testing rig in near-Earth orbit, something that is desperately needed for developing and testing complex prototypes of space equipment and components.

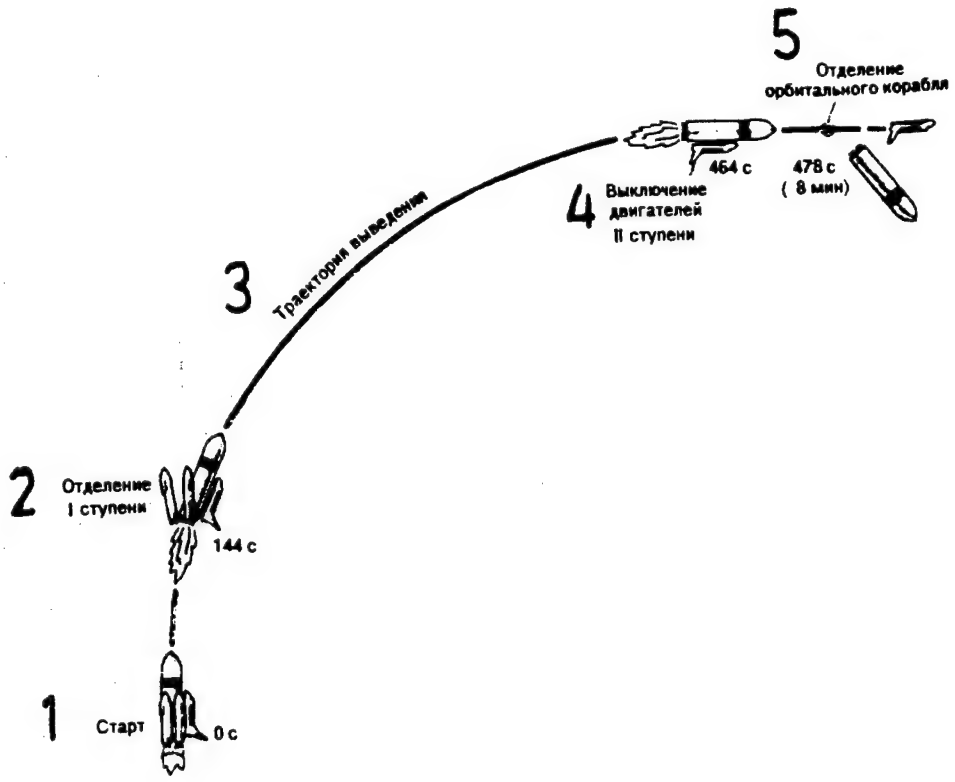
There is already a need for the employment of a new craft for domestic orbital stations, with their growing problems of resupply, repair, and servicing. One important feature, however, must be noted: the anticipatory development of the craft, in relation to other facilities, as a means of servicing, assembling, performing production, or doing research in space. The notion of the possibility of the parallel development of vehicles and complexes requiring servicing or assembly in orbit is unrealistic primarily because of the enormousness of the expense. The decision to create Buran came out of the plans to develop the domestic space program that were based on a technical forecast. Our experience tells us that some degree of uncertainty is acceptable here. After all, the creation of automated docking equipment and the Soyuz spacecraft and the creation of the first orbital stations and EVA equipment served as a solid foundation for a space research program of almost 20 years. Initially, however, it bore the character of anticipatory developments, as it were, in individual programs.

Moreover, the elements of uncertainty this time were allowed for by increasing the design margins in the specifications of the Buran craft. With allowances for such margins made on the basis of theoretical analysis and conjecture about hypothetical cargoes, the goal was set to design an orbital craft capable of transporting up to 30 tons of cargo and having versatile equipment for performing work in space.

A Wing, A Parachute, or Fuel?

Placing the orbital craft Buran into orbit is done in an almost traditional manner: the universal booster rocket delivers the craft to the threshold of near-Earth space, and the next steps to space orbit—two boosting impulses—are performed with the propulsion system of the craft itself, only to ensure that the fall of the second stage of the booster is safe for people below (it is sent into the waters of the Pacific Ocean).

The **return** is another matter. In the design of the Buran craft, the operational requirement for reusability was a new one. In general, this requirement meant the development of systems and constructions with large capabilities and guaranteed service lives, systems and constructions that could be reserviced repeatedly in terms of expendable materials and fuel, with a minimum of preventative maintenance or repair between flights. But



Injection of Buran by the booster

Key: 1. Launch, 0 sec—2. Separation of first stage, 144 sec—3. Injection trajectory—4. Shutdown of second-stage engines, 464 sec—5. Separation of orbital stage, 478 sec (8 min)

Ballistics of Buran flight

Key: 1. Launch—2. Injection trajectory on booster—3. Separation of orbital craft—4. Transfer orbit (preinjection)—5. Braking impulse—6. Transfer to reference orbit—7. Reference orbit (H, 250 km; inclination 51.6°)—8. Trajectory of extraatmospheric flight (after leaving orbit)—9. Entry into atmosphere (H, 100 km)—10. Descent trajectory in the atmosphere (descent range, 8,300 km; landing speed, 330 km/hr)—11. Landing

one of the key issues remained the choice of the method of descent and landing, which by and large determined the configuration and performance specifications of the craft.

In the creation of prototypes of new equipment, practical concerns often incline designers to solutions that are more stable, that are open to the fewest influences and possible changes. A classical example of this approach in the space program is the choice of a spherical shape for the Vostok descent vehicle. In principle, even then it was possible to think about designing winged descent vehicles. But the determining factors were those we didn't mention earlier: the need to solve many problems, the lack of experience, and, mainly, development schedules. The simplest solution was adopted, but the price was an uncontrolled descent and the parachute landing of the vehicle in the steppes.

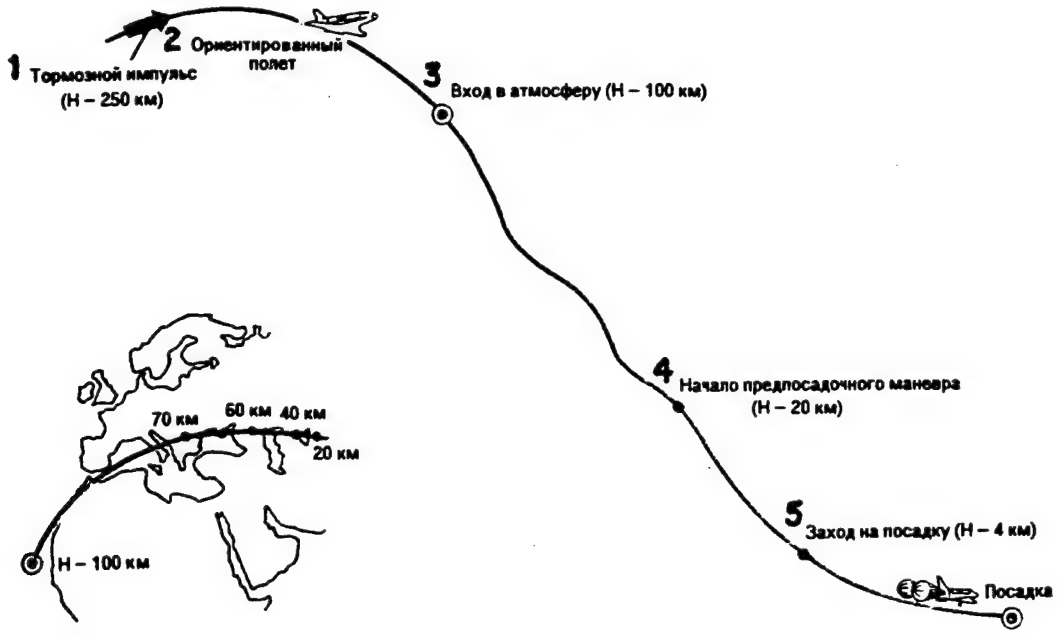
A variation was adopted for Soyuz-type craft in which there was a controlled descent with a low lift-drag ratio (about 0.3) and a vertical landing with a parachute-and-propulsion landing system. One can also imagine a variation of the landing without a parachute on the basis of liquid-rocket engines with the necessary amount of fuel.

Such solutions for a heavy, reusable craft are unacceptable primarily because, during descent in the atmosphere, there are relatively large positive G-forces and high surface temperatures that lead to materials being carried away and because of the diversity of the landing conditions at a site in an unprepared area.

Without getting into an examination of the various methods of descent and landing, let us note that **wings and a chassis for landing at an airfield like an airplane are needed**, and then the G-forces and temperatures will be moderated, and the craft will be capable of a broad maneuver during descent and during approach to the airfield zone, while the landing conditions will be stable and can be strictly controlled. Such a solution was adopted for the Buran craft.

The design and creation of a winged, reusable spacecraft have paved the way for solving important economic problems such as, for example, the automated landing of airplanes or the technology for producing new heat-resistant and construction materials. In addition, the creation of Buran has led to mutually enriching collaboration among the leading sectors of machine building: the rocket-and-space industry and the aviation industry.

The next step is the study of the possibility of creating an **aerospace** system that uses the Earth's atmosphere not only when returning, but also when moving into orbit. The experience gained in the designing of Buran will undoubtedly be useful in the development of this promising idea.



Спуск и посадка «Бурана»

Descent and landing of Buran

Key: 1. Braking impulse (H, 250 km)—2. Oriented flight—3. Entry into atmosphere (H, 100 km)—4. Beginning of prelanding maneuver (H, 20 km)—5. Final approach (H, 4 km)—6. Landing

Is Reusability Always Good?

With regard to space transport systems, a parallel is often drawn between reusability and economy. In fact, at first glance, using equipment over and over again makes expenses that much lower. It is worth adding a caveat here—if the equipment is the same. After all, reusability and a number of factors associated with it can alter and complicate a system, and, consequently, make it more expensive.

Let us illustrate this with a fundamental example. A match—as an object for making fire—is essentially disposable. Nevertheless, the invention of the lighter did not render match factories bankrupt. The diversity and specifics of conditions of application, the convenience of their use, the costs and demand in the market, the possibilities and availability of various kinds of production, the improvement of the technology—all these and other aspects result in the mutual competitiveness of matches and lighters. With mass production, there is a paradoxical turn: gas-filled lighters, whose principal feature was that they could be refilled and used virtually "forever," are now made without a refilling valve and are disposable—which is more beneficial.

To what degree should rocket-and-space equipment be either disposable or reusable? It is difficult to give an unambiguous answer. With the appearance of the first reusable designs and with their first experimental flights, two directions began to compete, and each of them, it seems, gravitates to a given area of application. Reusability as a means of improving efficiency of space equipment is a method of lowering costs while achieving the same end results. In placing cargoes into orbit in domestic vehicles, the advantages lie with disposable rockets, which handle the task at a considerably lower cost. Suffice it to say that one launch with Energiya handles a payload that is roughly three times that of Buran.

Another group of problems is one that is associated with servicing space vehicles and returning cargoes to Earth. Conducting operations involving the servicing of vehicles in orbit requires a spacecraft that, on a rather lengthy flight with a crew on board, can perform approach, station keeping, or docking; has a set of equipment for performing operations; and is capable of transporting the appropriate cargoes to and from the vehicle. Such a craft would have yet another task—resupplying and supplying orbital complexes. The nature of such operations, as with those associated with bringing cargoes down from orbit, presumes the return of the craft to Earth. On the other hand, the craft is outfitted with many of its own systems and a set of universal gear and special service equipment that are profitable to use again and again. All this creates a foundation for the repeated use of the craft, and the efficiency is determined by the correlation of launch costs and, for example, the cost of the vehicle repaired in orbit.

Thus, reusable systems are still not an efficient means of putting cargoes into orbit, and the primary area of their efficient use is in the servicing, supply, and resupply of space vehicles and orbital complexes.

The Buran craft is the first experiment in the creation of reusable vehicles in the Soviet space program. It gives reason to believe that we will, to a great extent, succeed in using it in the creation of future aerospace systems.

Buran and the Shuttle

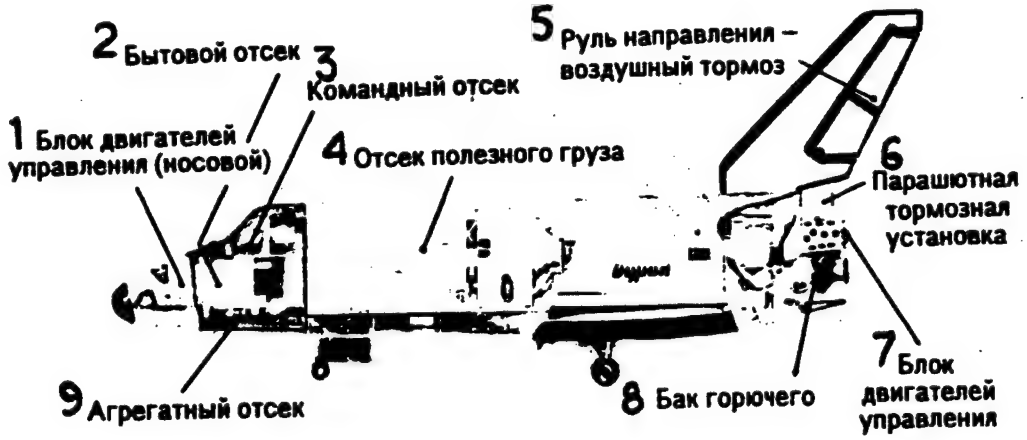
We must pause on the parallels and differences between two designs: Buran and the Shuttle. Externally, they are similar. But is that anything to be surprised about? The AN-12 and AN-24 aircraft, for example, which are designed on the basis of a progressive configuration, are quite similar to many foreign aircraft. There are plenty such examples in terms of equipment, and it is explained by a conformity of purpose and of problems to be solved and by a roughly similar level of scientific and technical know-how and technology.

Buran and the Shuttle were developed as piloted aircraft, and in space they have almost the very same purpose and capability. Hence the "similar" features such as a cargo bay that opens into space, a flight deck with control stations, powerful equipment for loading and unloading operations in space, and air locks for egress of the crew into open space. Both craft are equipped with all the typical systems for space flight, and their external appearance is dictated by the aerodynamic configuration necessary for performing the adopted scheme of descent and landing.

Buran and Energiya were designed considerably later than was the Shuttle, and the solutions adopted by the American specialists were taken into consideration. But we adopted our own solutions for Buran, solutions that corresponded to our own ideas about the best complex and the best specifications for the craft. The American specialists will probably also take our experience in creating Salyut and Mir into consideration when they develop new stations. One of the fundamental differences between the two craft is the injection. In the Shuttle, the sustainer engines of the second stage are located on the orbital stage, whereas the fuel is in an external tank. Energiya has a rocket unit in the second stage and is a versatile booster rocket capable of putting into orbit not only an orbital craft, but also any other cargo of around 100 tons. The Shuttle system does not have that capability, and its payload is limited to 29 tons carried in the cargo bay of the orbital stage. The first stages are vastly different from each other: two solid-fuel boosters in the Shuttle system, as opposed to four rocket assemblies with highly efficient liquid-fuel engines on Energiya.

This new injection system has made it possible to improve the performance specifications of the orbital craft, shed some weight, and simplify the component

Buran Design



Key: 1. Control engine unit (forward)—2. Crew living compartment—3. Control compartment—4. Payload compartment—5. Rudder-air brake—6. Parachute braking unit—7. Control engine unit—8. Fuel tank—9. Equipment section

Basic Technical Specifications of Buran

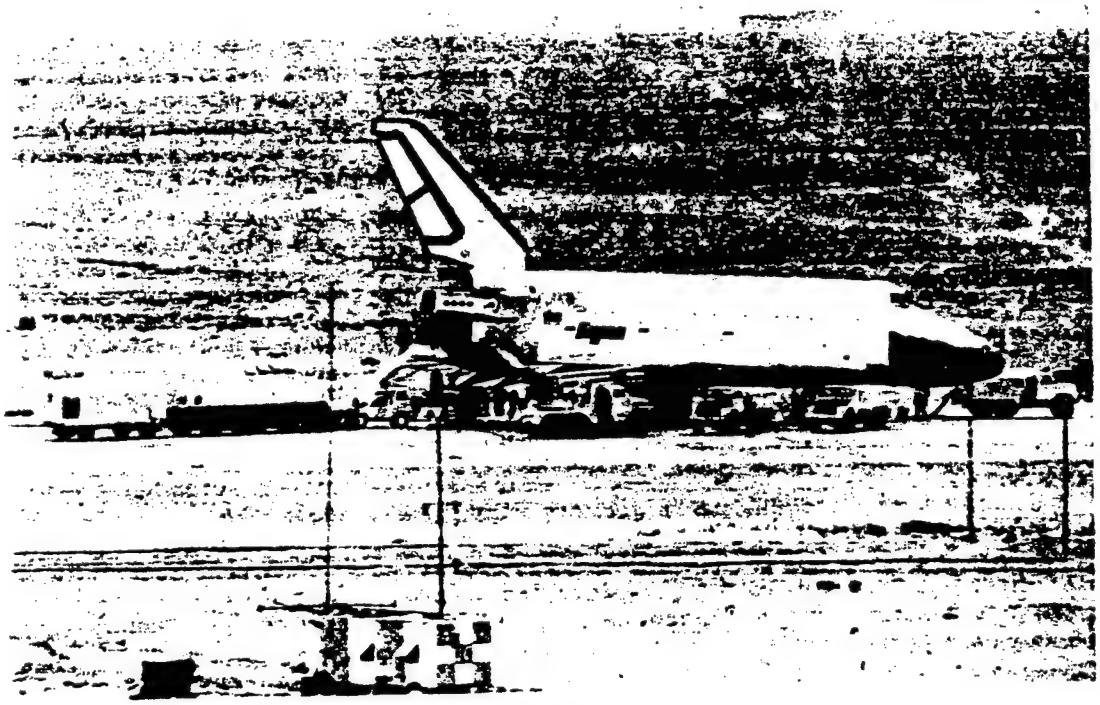
Overall height	16.45 m
Length	36.4 m
Wingspan	23.9 m
Fuselage diameter	5.6 m
Dimensions of payload compartment	4.7 x 18.3 m
Maximum launch weight	105 tons
Dry weight, without cargo	65 tons
Landing weight	82 tons
Maximum weight of cargo delivered	30 tons
Maximum weight of cargo returned from orbit	20 tons
Duration of flight	
Nominal	7 days
Maximum	30 days

configuration. The ship's lines, configuration, structure, systems, and equipment demonstrate original designs, one of which is the use of a unified propulsion system that has common tanks for all the control and sustainer engines and operates on an ecologically pure vapor (hydrocarbon fuel and oxygen as the oxidizer). It should be noted that domestic materials and technology were used to manufacture Buran.

The basic distinguishing feature of Buran is its automated landing. That makes it possible to perform pilotless launches, and it conforms to the traditions of the development of domestic piloted craft as versatile equipment. Nevertheless, in the design of the Buran-Energiya complex, we also used designs that are traditional for the Soviet space program: horizontal assembly in the assembly building, transport to the launch site by rail, placement of the complex in a vertical position right at the launch, and much more.

Prospects for the Use of Buran

The development of the craft took into consideration not only today's needs. Many cargoes for Buran, as for any other versatile system, await it in the future, and with them, new space operations. This means such things as servicing, repair, resupply and supply of space vehicles, and assembly and adjustment of large structures in space. The supply of orbital complexes of the future cannot be done without Buran. Suppose, for example, that, in time, the Mir station becomes an intricate complex with five modules, and one of the modules malfunctions unexpectedly. Say, a complex, unique electrooptical unit developed in an international collaborative program, becomes damaged. Buran, which is capable of delivering to the station virtually anything it needs and then returning to Earth, would help in that situation. Even the Mir module or the Salyut station could be placed in Buran's cargo bay (by folding or disconnecting the antennas and solar batteries).



Buran after landing (TASS photo)

The peaceful doctrine of the Soviet space program has been proclaimed more than once now. The Buran craft is no exception. In fact, how can a system be used in military strategy plans when its launch sites are known and its preparation for launch requires a relatively large amount of time?

The creation of the new versatile Energiya system and the Buran orbital craft have undoubtedly attracted the attention of the world community and of scientific and professional circles. And we hope that the collaboration of various countries on a contractual and commercial basis will serve to further strengthen peace on our planet.

Developmental Tests for Shuttle Orbiter

18660022 Moscow PRAVDA in Russian 24 Nov 88 p 3

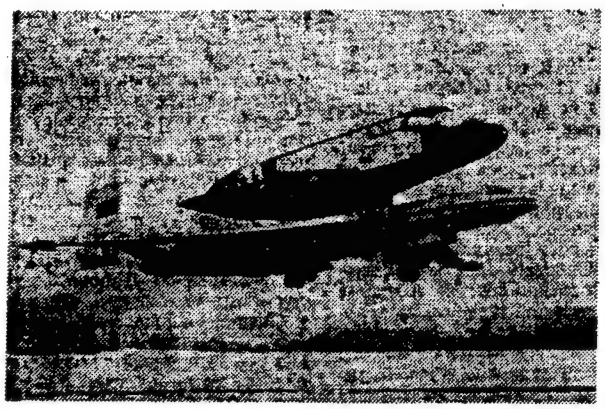
[Article by K. Vasilchenko, doctor of technical sciences and director of the Flight Research Institute, G. Lozino-Lozinskiy, doctor of technical sciences, general director, and scientific production association chief designer, and G. Svishchev, academician and director of the Central Aerohydrodynamics Institute [imeni N. Ye. Zhukovskiy], under the rubric "We Report the Details": "The Path to Buran"; first paragraph is PRAVDA introduction. Passages in boldface as printed]

[Text] **Since it is simultaneously an orbital spacecraft and an aircraft, the shuttle Buran was supposed to combine in itself the qualities of a satellite and an airplane. Buran's development posed for aviation science and industry a whole set of complicated scientific, technical and organizational problems, in the solution of which participated a comprehensive cooperative made up of academy and industrial institutes, higher education institutions, design bureaus and plants. Many thousands of scientists, designers, engineers and workers participated in the development and testing of the shuttle Buran's numerous systems, in the investigation of its characteristics and in the development of unique production processes.**

During Buran's development it was necessary to make a decisive qualitative jump from the speeds achieved by the best aircraft designs of around 3,000 km per hour to speeds of up to 28,000 km per hour during flights in the atmosphere and outer space.

The selection of a winged aircraft design for the aerospace craft made it possible to solve the most complex scientific and technical problem of a descent in the atmosphere with a change in speed from 8 km per second to 340 km per hour, with the capability of performing a lateral maneuver in the atmosphere of up to 2,000 km and a horizontal landing like a glider.

Buran has been shown repeatedly on television and in photographs, both at the moment of launch and during the landing. Nevertheless, its design and power system should be discussed separately. It was built according to the "tailless" aircraft design with a low-mounted, double-swept delta wing and aerodynamic controls typical of an airplane: elevons, rudder and trim flap. Special design



Flight of Transport Complex With the Orbiter

features have been dictated to a significant degree by the requirements for protection against aerodynamic heating. For this purpose, the thickness of the wing and the radius of the bluntness of the fuselage's nose section have been increased, and reusable thermal protection systems have been developed. Buran's entire surface, except for the wing's leading edges and the fuselage's nose, has been covered with 38,000 tiles, manufactured from fine, pure-quartz fibers. The wing's leading edges and the fuselage's nose have been made from a refractory graphite material. In order to permit the conducting of unloading and loading operations in orbit, a cargo hatch has been situated along the greater part of the fuselage's length. This is an enormous longitudinal opening enclosed by doors. Located in the tail section are the orbital maneuvering system engines. In order to maintain control in the atmosphere's rarefied layers, Buran has nose and tail units with gas-dynamic thruster nozzles.

One of the basic problems during the development of the orbiter's airframe was that of attaining aerodynamic characteristics that would ensure performance of the mission in all sectors of the flight during the descent from space—hypersonic, supersonic, transonic and subsonic. The scientific problems which confronted aerodynamics experts required an integrated approach using the latest achievements in theoretical, applied and experimental aerodynamics. The development of models, test stands, a tensometric balance and other equipment sharply increased the experimental aerodynamics base's productivity and, at the same time, thereby facilitated the development of other areas in domestic aviation and space technology. Inasmuch as the many flight conditions and physical phenomena during a descent from orbit have not been completely simulated in wind tunnels, special calculation techniques have been developed at the Central Aerohydrodynamics Institute for determining the aerodynamic characteristics with the aid of powerful computers.

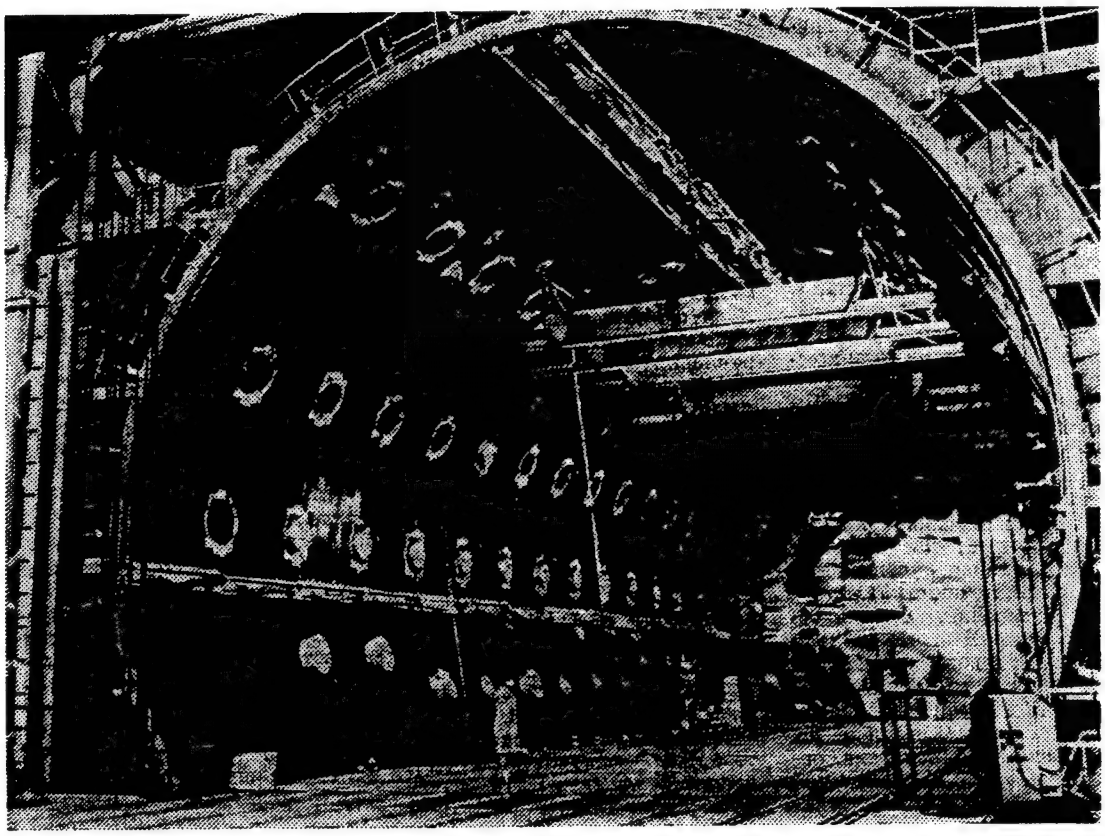
Tens of thousands of wind tunnel tests, tests in airborne protypes and precise calculation techniques have made it possible to determine, with a high degree of reliability, the airframe's aerodynamic characteristics, which are vital primary data for a large number of systems developers from various departments.

Ensuring the craft's durability was far more complex than any of the problems with which scientists and engineers had had to contend over the course of the entire history of the development of aviation. It was necessary to develop a light-weight design capable of operating for a prolonged period under exceptionally severe conditions. For the first time, a reusable domestic winged vehicle was supposed to be able to withstand very intense vibration and acoustic stress from powerful rocket engines and the supersonic airflow, which can cause metal structures to fail. And later, during descent from orbit, it would be subjected to heating up to temperatures at which metal melts.

These conditions were duplicated in laboratories during the testing of the durability and thermal condition of the shuttle Buran, in which nontraditional designs and new composite materials have been used. Aluminum and its alloys were replaced by new, advanced alloys which possessed higher modulus characteristics—titanium, beryllium, boral [boralyuminiyevyy] and niobium. Nonmetallic and composite materials with various fillers have been developed. Materials science experts from industrial and academy institutes have made a large contribution to this work.

One of the most important developments was that of the thermal protection covering, which has to be reusable, have a minimal specific mass, possess high heat-resistance, have sufficient strength, have a minimal thermal expansion coefficient, and be neutral to pure atmospheric plasma and radiotransparent. The development of tile thermal protection which withstands temperatures of up to 1,300 degrees [C] and, in the carbon nose section of the fuselage and the leading edges of the wings, up to 1,500 degrees [C] required a new industry with a high level of efficiency and technology, innovative ideas, unique research installations and basic and applied research in the fields of scientific instrument-making, gas dynamics and heat exchanges processes. Participants in these operations, along with institutes of the aviation and chemical industries and nonferrous metallurgy, included scientists from the USSR Academy of Sciences, the UkSSR Academy of Sciences and higher education institution laboratories.

The results of the experimental research conducted on models in gust and shock tunnels and numerical calculations have been used to develop a temperature profile that charts the temperature distribution over the entire surface of the orbital aircraft. Information has been obtained about the effect that intertile gaps and tiles that have fallen off have on heat exchange. Used as the final test were the launches of maneuverable satellites of the Cosmos series—Cosmos-1374, -1445, -1517 and -1614. These aerospace vehicles, the first in domestic practice, made it possible to examine the operation of the tile



Heat-Resistance Vacuum Chamber for Testing Buran's Thermal Protection

thermal protection and the carbon-material nose blunting under conditions close to those under which the Buran's thermal protection operates.

The experimental developmwnt of the strength of the load-bearing structure and the effectiveness of Buran's thermal protection turned out to be feasible thanks to the use in the aviation industry of unique test stands: heat-resistance vacuum and acoustic chambers, a static testing chamber and a complex of vibration-testing units. In the static chamber, for example, the airframe was subjected to the action of the enormous forces which arise in the orbital insertion phase, when the structure has not yet heated up.

Two-hundred fifty-six computer-controlled force generators could act simultaneously on the craft. The data-processing computer system recorded during the testing process more than 15,000 parameters by which the experiment was controlled, and the structure's condition was evaluated on a real-time basis.

A heat-resistance vacuum chamber, with an working space 14 m in diameter and 30 m long, has made it possible to examine the behavior of the large thermal protection sections of the airframe under heating and load conditions which occur during the entire flight trajectory. High-temperature infrared heaters, with a total power of up to 13,000 kilowatts and covering 95 individual zones, each of which is controlled by a computer according to its own program, ensured heating of the test structure which was close to the actual heating, with a maximum temperature of +1,500 degrees. A cooling system which uses liquid nitrogen simulates the cooling down of the orbital aircraft in space to -130 degrees. Five thousand sensors of various types "track" the behavior of the test structure.

Of essential importance is the problem of control of the ship's automated landing right up to the moment of coming to a stop on the runway. The heightened requirements necessitated development of extra-precise information measuring systems. Fundamentally new electronic landing systems and air-traffic data collection and processing systems have been developed and tested, and new approaches have been developed to interlinking and integrating all the information systems and checking their reliability.

A full-scale test stand for Buran's equipment made it possible to conduct, with a great degree of accuracy, a half-scale simulation of an actual flight. More than 1,400 "flights," with the introduction of unforeseen situations, have been conducted on the stand. The total number of programs developed for carrying out the test stand's operation exceeded one million.

The total crew training time on the flight-dynamics test rig, where flight problems were worked out and an evaluation of the ergonomic characteristics of the control and display elements was made, amounted to 3,200 hours.

The next step of the program was the testing in the Flight Research Institute of a family of models based on extensive modification of aircraft of the MiG-25 and Tu-154 series. Airborne laboratories, which completed nearly a thousand flights, assisted the research on algorithms for the landing manuevers and helped check and refine the ground system and the on-board equipment.

In order to ensure the quality of the craft, during the process of its development in the aviation industry, an automated system was developed for evaluating the orbiter's operating condition. The system includes a computer system which stores information about the testing results, mathematical design models, and production information and data obtained during the tests and the operation of the orbiter. For example, today, each of the 38,000 tiles of the thermal protection has in the computer system its own record, which accompanies the tile from the moment of its appearance, in the form of a computer program for manufacturing, to the end of its service life. This makes it possible to know the actual condition of the thermal protection and to guarantee its reliability. Such "tracking" systems for quality are being developed in support of the Buran's entire operating program.

Within the Buran program, 123 new types of devices are being used to monitor and diagnose defects in all stages of production of the ship's units and assemblies. Many of them are superior to similar domestic products and have found application in the automotive, light-industry and shipbuilding sectors and even in municipal services.

The flights of an aircraft-analog helped to confirm the correctness of the designs and to perfect the interaction of the on-board systems and the airfield systems. This was the selfsame Buran, but equipped with four turbojet engines which made it possible to take off and make a landing "like an airplane."

Finally, the day arrived when, in actual flight, the spacecraft Buran itself controlled its motion during landing using radio-controlled correction of the trajectory. At the landing airfield, high-precision beacons created an information radar field. Buran's radio receivers received the signals and transmitted them to the on-board computer which calculated the deviations of the actual trajectory from the specified trajectory that alone could bring Buran to the landing strip with acceptable speed and accuracy.

Covering 20,000 kilometers from the moment of the braking pulse to the landing, Buran confidently handled all the speed and temperature segments, from the hypersonic to the "ordinary," and found its "own" runway. In contrast to that of an ordinary aircraft, this was an unpowered landing along a very steep trajectory which would seem like a freefall to an uninitiated person. The completion of the program and the accuracy of the landing are beyond words.

The accomplishment of the project, of course, required large expenditures. However, in addition to the direct result, they can be justified by the new developments, which are useful not only in the aviation and space industry. The nearly 30 new materials developed for Buran even now are becoming the foundation for advanced developments in practically all the machine-building sectors. The experience obtained on Buran's combined test rigs has also opened the way for progress in our machine building.

The test complex for perfecting the Buran's structures is even now serving the development of various types of aircraft and new models of motor vehicles and agricultural equipment. The introduction into the practice of machine building of the techniques and means for the realization of highly reliable machines will lead to a qualitative jump, which is a most important task in our country.

Of enormous importance for passenger and transport aviation is the development of an automated landing system, which will lead to actual all-weather air service. After a more than 3-hour flight in space and the atmosphere, at the moment when the craft stopped on the runway the deviation in time from the program amounted to 1 second, while the deviation of the ship's axis from that of the runway amounted in all to 1.5 meters.

The computer-aided design and computer-aided operation monitoring systems, the automated production tooling, and the elements of the automated quality-assurance system will undoubtedly be reproduced in the economy. The store of program packages for the various classes of computers used in the planning amounted to more than 700 units and is a national asset.

Indisputable is the practical benefit to the economy of the means and techniques for non-destructive testing. Some of them are already in use in series production lines and will be circulated in hundreds of copies.

Thus, the tests of Buran have become a test of our scientific and technical arsenal. And these tests have been passed with flying colors.

General Designer Describes Buran Flight Control, Autopilot Systems

18660024 Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 7 Dec 88 p 4

[Article by V. Lapygin, general designer of Buran's control system, doctor of technical sciences and professor: "From Space Orbit to Landing Strip; A Unique Automatic Control System Piloted Buran Faultlessly"; first paragraph is SOTSIALISTICHESKAYA INDUSTRIYA introduction. Passage in bold italics given as printed]

[Text] ***The skill of the pilot and the operator in the MiG-25***

chase plane made it possible for millions of television viewers to see how confidently the reusable spacecraft came in for the landing. It is difficult to convey the emotional stress of those minutes—even though there was no crew in Buran's cabin. Nevertheless, we, the control system's developers, had no doubts that the "shuttle" would come down precisely on the runway and successfully complete its first flight. By the way, this confidence did not leave the developers for even one minute during any leg of the flight. Indeed, when the craft and the software were being perfected, hundreds of tests were conducted on the test stands and the analog-digital system that simulated the ship's motion in most varied—routine and non-routine—situations. And the last stage was repeatedly checked in an airborne laboratory and the Buran simulator, which were equipped with exactly the same system.

The problems it was called upon to solve were so varied and the system itself so complicated that it is simply impossible to tell about everything in a newspaper article. Judge for yourselves: installed aboard Buran are around a thousand instruments, in which the most precise electromechanical equipment has been combined with the latest equipment in electronics.

Figuratively speaking, the Buran's control system has its own "eyes," "brain" and "hands." Any kind of comparison leaves much to be desired and this one all the more so, but, at the least, it makes it possible to explain to our readers in more or less familiar terms the basic problems and the techniques for solving them. The system is supposed to determine where the ship is at any given moment—as you can see, it performs the functions not only of the pilot, but also of the navigator. The automatic equipment selects the necessary trajectory and "keeps" the ship on it. Finally, it ensures the Buran's stable orientation in space.

Physiologists figure that a person receives the overwhelming majority of his information about the surrounding world through his sight. And the basic stream of information necessary for control of the space "shuttle" comes from the flight director system [kompleks komandnykh priborov]—this is why, with a certain stretching of the point, it can be considered to be the ship's "eyes." The system's basic components are three gyro-stabilized platforms with three accelerometers—instruments for measuring accelerations caused by the engines' operation and the atmosphere's influence. Nine angular velocity sensors—three for each of the three mutually perpendicular axes—are rigidly fixed to the ship's hull. In certain motion segments of flight, use is also made of accelerometers rigidly fixed to the hull.

The gyro-stabilized platform provides an unchanging orientation in space for the accelerometers installed on it. Usually, for this purpose, it is enough to have a three-frame suspension, although such a design has a limitation on one of the angles of rotation. For this reason, for Buran, with its extremely complicated trajectory of motion, it was necessary to develop a platform with four frames, which would ensure stable orientation with any of the ship's evolutions. Thus, instead of the three traditional angles, the values of which make it possible to control motion, it was necessary to use four, introducing complicated conversion algorithms. This example, just one of many, shows that, during the development of the Buran's control system, even the application of known solutions required a great deal of inventiveness.

The information from the flight director system enters the "brain"—the on-board digital computer system (BTsVK). Four of the same type of high-speed, large-memory computers operate in parallel during the flight, solving the same problems. And, even if two of them fail, the control system does not lose its ability to function.

And, finally, the automatic pilot's "hands" are a system of actuators and their servo systems. It consists of several aerodynamic surfaces—the elevons, the rudder, the air brake and the trim flap—and two orbital manuevering engines and 38 relatively low-thrust control engines, which make up the Buran's consolidated propulsion system. It goes without saying that such a combination of control units—aerodynamic and reaction—which was necessary for the Buran's flight both in space and in the atmosphere, at the minimum, doubled the complexity of the developers' task.

Any machine, even the most advanced one, is lifeless as long as its "brain" is like a blank sheet of paper. The algorithms realized in the on-board programs occupy a special place in the operation of the Buran's control system. Only after the programs have been fed into the on-board computer memory and all the systems have been checked does the ship "come to life." The developers of the Buran's on-board systems also participated in the development of the software, along with our scientific production association's workers. For the programs, the Prolog [Prologue] and Dipol [Dipole] high-level languages were developed jointly with the Applied Mathematics Institute imeni M. Keldysh.

In order to perfect the algorithms for motion control and navigation—including descent, flying to the landing field and coming in for a landing—an analog-digital system was developed in which the Buran's motion was simulated on general-purpose computers. This was, figuratively speaking, a "mathematical flight" in the computer's womb. Meanwhile, the interaction of the instruments and systems was polished on the integrated simulation test stand. The stand was the only instrument which made it possible to check the entire software system under conditions in which all the ship's on-board systems, without exception, were operating—naturally, not the actual ones, but their mathematical models. The computer experiment made it possible to simulate repeatedly Buran's flight from launch to landing.

It is precisely on this test stand that all the on-board software was joined into a unified system and a unified "model of the memory" used to control Buran during actual flight was obtained.

And now we come to the launch day. The day before, the weather at Baykonur was excellent, but, on Monday, it worsened severely—a low cloud cover appeared, along with rain and wind. The question arose: do we launch or not? The senior engineering staff made the decision to go ahead and launch. What could be better than a chance to test the control system under severe weather conditions?

Usually, before the launching of any spacecraft, the gyro-platform is oriented in space with a high degree of precision. Along the vertical by its own accelerometers and, in the horizontal plane, using an extremely complex optoelectronic azimuth sighting system. There is such a system on the Energiya launch vehicle—it is precisely a check in its instrument compartment that compelled the automatic equipment to cancel the launch in October [1988] at 51 seconds before launch time.

In order to avoid conducting such a complicated operation with the Buran's platforms, a so-called analytical sighting was used. In the orbital insertion phase, the ship received navigational information from the launch vehicle's control system. The on-board digital computer compared it with its own navigational information and computed corrections, making the requisite azimuthal direction of the Buran's platforms more precise.

But, what if communication between the Energiya and the ship were interrupted? The control system was ready to shift at any moment to autonomous solution of navigation problems. Incidentally, after separation, this occurs routinely.

The separation of Buran from the booster's second stage and its movement away from it represent the most crucial moment of the flight. As soon as the powerful separation assemblies send the ship off into independent flight, the control system turns on the low-thrust engines. Remember, there are 38 of them, and the complexity lies in the proper selection of those that will produce the maximum thrust in the direction of the "shuttle's" departure and the minimum moment around its center of mass. Otherwise, the ship could begin a turn during which the stern or the nose could hit the second stage of the rocket.

After the ship had entered a circular orbit, the automatic equipment oriented it so that the left wing was pointing down. Such a position in subsequent flights will be the in-orbit operating position—it is the most convenient for using the astronomical and radio equipment. In this leg, the control system maintains the Buran's attitude, trying to expend as little fuel as possible.

The automatic equipment effects highly complicated evolutions even during the descent from orbit—it turns the Buran tail-end forward, provides the necessary braking pulse and then orients the "shuttle" again so that it enters the atmosphere at a specified angle. Then, it it must reduce the speed to the design speed of 520 meters per second and, after a distance of more than 8,000 kilometers is covered, pilot the craft to the calculated point. The control system did all this with a high degree of precision.

But the most difficult part, perhaps, was the leg of the flight between the altitudes of 80 and 40 kilometers—here, the ship experiences the maximum thermal effect. The Buran shuttle is covered with a thermal protection layer made up of tiles which can withstand the high temperature, but, any material has its own limits, which, naturally, limits the motion parameters. This limitation frequently is at variance with the guidance tasks. The algorithms which predict the ship's motion up to the final point flexibly formulated such a descent trajectory, which approached the temperature limitation, but did not exceed it under any circumstance. The control system effected a somewhat similar "passage along the edge of the precipice". And in no less simple fashion was the stabilization of Buran effected, first using only the low-thrust engines and then the aerodynamic actuators. It was necessary to maintain very precisely the proper angle of attack. Otherwise, the heat could disintegrate either the cabin windows—if the angle were too small—or the edges of the orbital maneuvering engines—if it were too large.

The problem solved by the control system in this leg is truly unique. This is why those involved with the descent waited with such tension for the appearance of the telemetry information after the blackout caused by the plasma ionization. And when, at an altitude of a little more than 46 kilometers, the radio communications became stable, it then became certain—the Buran is proceeding precisely along the nominal trajectory and would be at the landing strip.

Each scientist, designer and engineer experiences legitimate pride, having coped with this complicated problem. I think that the group of developers of the Buran's control system has every right to be proud of its child.

Specialists at Flight Control Center Discuss Shuttle Computer Systems

18660025 Moscow SOVETSKAYA ROSSIYA in Russian 2 Dec 88 p 3

[Article by Aleksandr Nemov, including a discussion with V. I. Lobachev, director of the Flight Control Center, and V. N. Pochukayev, director of the Flight Control Center's Ballistics Service under the rubric "Some Encounters With the Specialists Who Prepared the Buran for Its Unique Flight": "Programmed Space"; passages in boldface given as printed]

[Text] It seems as if it was quite recently. Hundreds of displays located in the various rooms of the Preparation and Launch Control Center (TsUPP) and the Flight

Control Center (TsUP) lit up at the same time. The computer system which "tied" the thousands of mechanisms which control the launch of the Energiya launch vehicle to the reusable Buran spacecraft came alive. The movement of the numbers on the screens indicated how the filling of the tanks of Energiya and Buran with liquid oxygen and hydrogen was going, how the pressure in the pipelines was increasing and how the temperature in the compartments was falling. Thousands of parameters flowed along little information "rivulets" into a single "deep" river, which only a computer system which performed tens of millions of operations per second was capable of absorbing. In the last few minutes before the launch, only a computer could control the endless number of mechanisms, instruments and sensors located in the "insides" of Energiya and Buran. And on the ground, understanding what was going on required an even more powerful computer. Computers on Energiya and Buran made decisions, and others on the ground explained to the people: "this has been done for this reason and that..."

The check numbers said that the fuel supply necessary for the launch had been received. The computers of Energiya and Buran begin the final check of all systems. If any sensor signals danger—be it the presence in a compartment of the least concentration of a dangerously explosive mixture of oxygen and hydrogen or that one of the hundreds of prelaunch operations has not been performed—the computer will send a "stop" signal and the launch will not take place. Otherwise, a growing chain of malfunctions can lead to an explosion... Telemetry information from the sensors of Energiya and Buran also goes to the ground.

The long minutes dragged on. Finally, the computer gave the command to launch. We see on the display the numbers which indicate how the dozens of pumps, which are capable of injecting tons of fuel into the combustion chamber every second, are whirling. We do not hear the roar of the superpowerful engines, but the numbers indicate precisely how the trembling is running through the 2,000-ton cigar during these seconds. A difficult struggle is going on against the earth's gravity. Energiya rushes into the sky...

After 10 seconds, it is already at an altitude of 200 meters. Its motion accelerates. The ground is being left farther and farther below. As before, the launch vehicle and the ship are "signaling" about themselves every second, "dumping" thousands of parameters to the ground.

In the Preparation and Launch Control and Flight Control centers, the voice over the PA system rings out: "40 seconds, flight is stable..." But suddenly, it was as if an electric pulse had run through the specialists at the displays. Energiya's on-board computer made the decision to turn off one of the propulsion systems. Some kind of malfunction had arisen in the fuel feed. Energiya has four strap-on units and, even if one of them fails, the flight can still continue—Buran will go into a space orbit all the same.

It seems as if time has stopped. Seventy seconds into the flight. The on-board computer turns off another propulsion system. An analysis made by the FCC's computer system indicates that now Buran will not make it into space. What should be done? What will Energiya's computer do? We find out in a second—it decided to perform a return maneuver. It seems incredible that the rocket's computer makes a decision all by itself, without any kind of consultation with the ground, with people. After reviewing thousands of possible variations, it settled on the optimum one. Energiya changes course and, after describing an enormous curve with an exit at an altitude of 100 kilometers, turns in the direction of the launch site. At the landing complex, the command arrives to prepare for the return of the spaceship. The MiG-25 observer plane takes off, and the servicing vehicles are set in motion. Buran separates from the launch vehicle. Energiya's computer transmits the stored information to its computer. It must plot out a course to the landing strip, while the launch vehicle is fated to perish on the Kazakhstan steppe, 400 kilometers from Baykonur.

After 20 minutes, losing speed, Buran is already arriving at the runway. The on-board computers, reacting instantly to the smallest gusts of wind, delicately control the massive "little bird." Finally, it touches the ground and, after a short run, stops... Hundreds of millions of rubles have been saved.

The director of space flights, Cosmonaut Valentin Ryumin, turned off his own display and got up out of his chair. The training exercise was over. Hundreds of specialists and operators left their own positions. There was a short break. And then, again, a launch and the simulation of various "non-routine situations"... It was hard to believe, but the entire flight of Energiya and Buran was a game of the imagination of powerful computers. Some computers simulated the behavior of all the units of the rocket and space complex and the change in the parameters, others took care of the transmission of information, simulating its movement from the rocket to the space communications satellites and the ground tracking stations, while yet others, based on this, controlled the flight of this "hypothetical object"... But why "hypothetical"? There is an actual one which, in fact, completed a leap into orbit on 15 November 1988. This can now be said openly: thousands of Soviet scientists and designers spent more than 10 years working toward this victory. Such integrated training exercises have been going on for nearly a year.

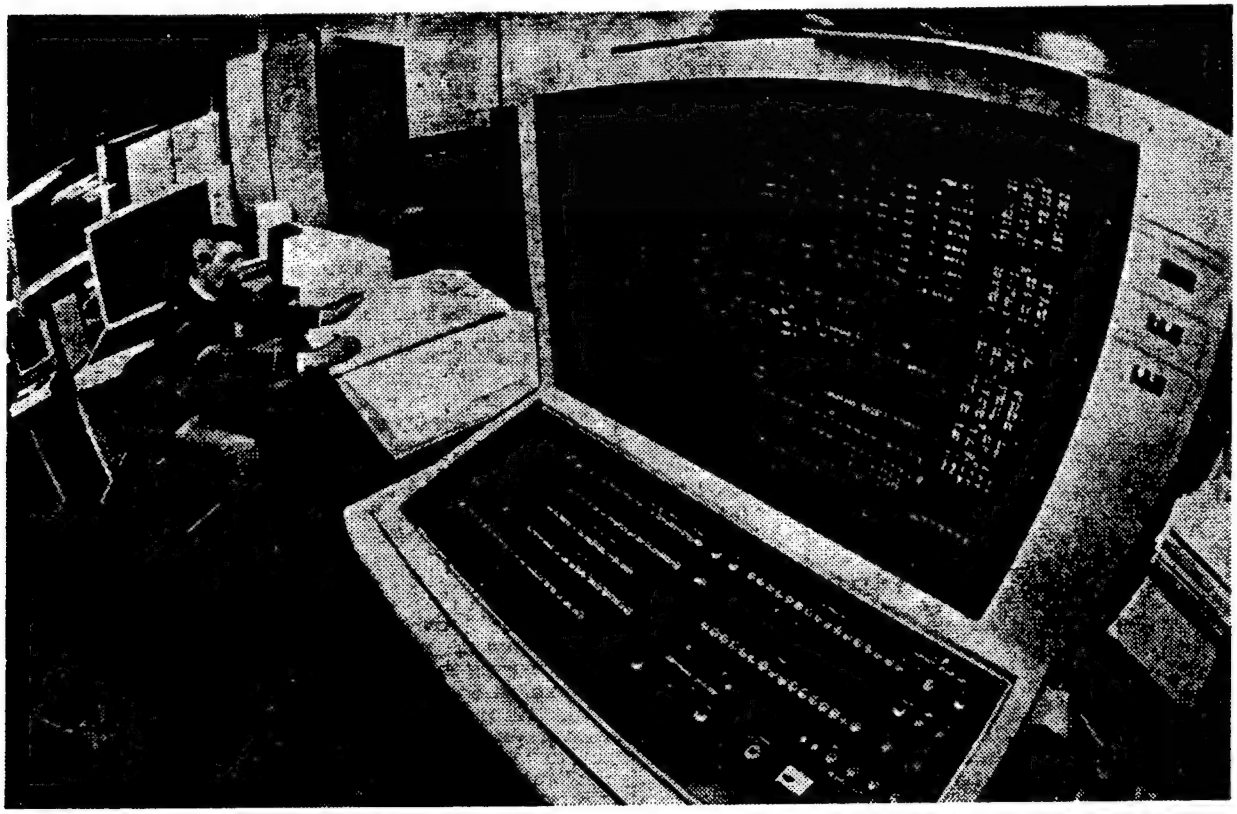
The attention of the entire world was riveted on Buran's flight, and it was also being attentively followed in the USA. And not just because the American Space Shuttle ships now had competition. The launching of Energiya

and the unmanned flight of the Soviet reusable craft signified a breakthrough by the USSR to the most advanced technologies and, primarily, in the field of computer equipment. This needs to be explained in more detail. At one time, American military specialists said that the "Soviets' lack of the necessary computers and expert programmers" was one of the main reasons the USSR could not compete with the USA in the development of a "Star Wars" system. Indeed, "Star Wars" is a network of special ground stations and orbital stations tied together by a unified control. The computers are supposed to keep track of thousands of objects on the USSR's territory, accurately calculate missile trajectories if Soviet ballistic missiles are launched, and, if a special command is issued, destroy them in all stages of flight. In the opinion of the experts, the Soviet Union was not capable of developing such a complex computer system. And, even though M.S. Gorbachev has repeatedly emphasized that the USSR is opposed to "Star Wars" systems for reasons of principle, since their development would torpedo the agreement on limiting nuclear arms, some saw in this position an acknowledgement of our weakness. But effecting Buran's automated flight and working with many facilities on the ground and in space are involve problems that are similar to those of the "Star Wars" systems. Which means, there are electronic experts and expert programmers in the Soviet Union.

V.N. Pochukayev, director of the Flight Control Center's Ballistics Service, speaks out: "Energiya and Buran are space systems of the future. Judge for yourself. How do we control the Soyuz-TM now? Information is sent to the ground from the on-board computer. We in the TsUP calculate the trajectory and flight parameters and send these data back into space. Figuratively speaking, the TsUP sets up markers for the Soyuz-TM on the space road—'slow down' here, 'turn' here. It is not at all like this with Energiya and Buran. Their on-board computers make the decisions themselves.

"Or, for example, during the launching of a Soyuz-TM, it is known precisely that, if everything is going fine, then, after 300 seconds, the ship will be at an altitude of 150 kilometers. But during Energiya's flight, we do not know beforehand how long it will take it to fly to this altitude. The rocket itself determines the optimum trajectory and time of motion to its goal—reaching an orbit of 150 kilometers. And it can choose how to do this."

"What do you mean the computer itself decides?" says **V. I. Lobachev, the director of the Flight Control Center,** entering into the conversation. "All its actions are programmed by people. In order to do this, it was necessary to obtain a large volume of additional information and to conduct thousands of experimental tests. Energiya and Buran and their individual units were checked on special test stands and tested in wind tunnels. Special



mathematical modeling techniques were developed. All this made it possible for the specialists to represent clearly what decision must be taken if, for example, an engine fails or there is a high-velocity wind during the landing. And only after such checking were these data transferred into the computer's memory by hundreds of the best programmers.

"One fact, at least, reveals the complexity of the problem. As is known, during the return from space, 38,000 refractory tiles protect Buran from heat damage in the atmosphere's dense layers. So, from the moment of manufacture to the moment of launch, each tile is accompanied by a special computer record, i.e., at any given moment, there is in the computer all the information about the thermal protection covering."

[Nemov] "What are the principal differences between the Energiya-Buran system and the [U.S.] Space Shuttle?"

[Lobachev] "At the very outset of the design process, the Soviet designers adopted a different configuration for the reusable system and a different sequence of flight tests. The American configuration of the reusable system does not permit the use of any payload other than the orbital craft. This arrangement is less of a general-purpose one and more of a pragmatic one—with maximum re-use of the system's basic components and with manned flights from the first launch on.

"Our configuration is the two-stage Energiya launch vehicle with the Buran reusable ship placed on it. Such an arrangement makes it possible to use any type of heavy payload—not just the orbiter—and, moreover, to conduct autonomous flight testing of the launch vehicle, which was successfully accomplished with Energiya's first launch on 15 May 1987.

"Because of crew safety considerations, the first flights of our orbiter were, from the very outset, set up as unmanned ones, which is customary for the Soviet space program."

V.N. Pochukayev: "I would like to add something. Energiya's first stage consists of four strap-on propulsion units, which, for all practical purposes, are independent rockets. They can be started individually, like small boosters. In my opinion, this is technologically efficient and will lead to a reduction of expenditures for space flights. All the more so since these strap-on systems, in the near future, will be recoverable, descending by parachute after burnout."

[Nemov] "The important theme of the economics of the exploitation of space has been touched upon. How profitable is the development of such complex systems as Energiya and Buran?"

V.I. Lobachev: "Today, the launching of nonreusable craft, for example, the Soyuz-TM, costs less. But Buran has just been born. It is in the flight-design testing stage. From the aviation industry's experience, it is known that the first test models of an aircraft are 10-20 times more expensive than the subsequent, mass-produced models. This applies as well to Buran. Indeed, the very control system, which includes hundreds of thousands of control programs, has already been developed. And it merely needs adjustment for later flights. Also in Buran's favor are its broad possibilities. It is capable of "removing" from orbit various objects and delivering them to the ground completely intact. And, indeed, up till now, we did not have any method for rescuing any kind of expensive space satellite if it broke down. But, if you want to talk seriously about profitability, then the development of the Energiya-Buran system represents the acquisition of technologies which will determine the face of scientific and technical progress for the next 20 to 30 years. For example, for the space liner, 30 new materials have been developed, among which are the unique heat-resistant materials made from quartz fibers and carbon compounds or the superstrong alloys that have been produced—beryllium, boral [boralyuminiyevye] and niobium.

"Also of major importance is the development of program packages for controlling such complicated objectives. The programs, I think, will find widespread application in the most diverse fields—for example, in aviation, for carrying out automated landings of aircraft. The main thing is to accelerate the introduction of these advanced information technologies. For the time being, unfortunately, we cannot say that the space industry's experience is finding rapid applicaton in other sectors. Here, we need to learn from the Americans."

V.N. Pochukayev: "I would note that our specialists are willingly responding to various suggestions. For example, the USSR State Traffic Inspectorate [Gosavtoinspektsiya] has just turned to us. They need help in developing a completely automated control system for motor vehicle traffic in Moscow. All the traffic lights should operate in a rhythm which is optimum for traffic capacity. There are thousands of traffic lights, tens of thousands of sensors under the pavement and hundreds of thousands of motor vehicles. And, although this problem is not simple, the models developed on Buran make it possible to solve the problem rather quickly.

"We could help meteorologists. As we know, accurate weather prediction would save billions of rubles. But, in order to predict the weather, accurate meteorological measurements are needed of the country's entire area. How are they obtained now? You have a weather station somewhere (for example, on the Kola Peninsula), and the people take readings from instruments several times a day (wind speed, temperature and so on) and transmit them to the weather center. It is clear that you cannot establish a large number of such stations. The working conditions are difficult (after all, they also have to be

located on ice fields, on the tundra, in deserts and in the taiga), and their upkeep is costly as well. But it is possible to establish an automated weather station, without any kind of staffing. It would constantly transmit information to the center via the communications satellites.

"In a word, Buran's flight is the prologue to a new stage of the scientific and technical revolution."

[Nemov] "Energiya's launch was an extremely crucial step. Were the specialists responsible for control—an important part of the program—very nervous?"

[Pochukayev] "It has already been mentioned that we spent more than 10 years preparing for this flight. During the last six months of that period, thousands of people worked without a day off. The Flight Control Center's specialists were no exception. The apogee of the enormous stress was, perhaps, at that moment when, on the 29th of October [1988], Energiya's launch was canceled. Therefore, the tensions attending the preparation and launch on the 15th of November [1988] are understandable. During Buran's first test flight, there was no avoiding nervousness and comments on the operation of the ship's individual on-board systems, but not one of them was significant or affected the completion of the flight tasks on the whole.

"Buran landed 1.5 meters off from the calculated axis and only 5 tiles of the thermal protection system, out of 38,000, "flew off" during the descent. The only cause for regret is the fact that many people have still not managed to get some rest. After Buran's return, the Phobos interplanetary station began communicating with the TsUP (it is already approaching Mars), data from space about the operation of all the systems of the Mir-Kvant orbital complex were arriving every second and dozens of other space facilities were in the Control Center's field of view.

'Energiya' Booster Said To Open Way for Space Telescopes, Antennas, Lunar Observatory

18660103 Alma-Ata KAZAKHSTANSKAYA PRAVDA in Russian 8 Jan 89 p 4

[Article by A. Cherepashchuk, director of State Astronomy Institute imeni Shternberg]

[Excerpt] At the 20th General Assembly of the International Astronomical Union, which was held in Baltimore (USA) in August of 1988, N. Kardashev, corresponding member of the USSR Academy of Sciences and deputy director of the Institute of Space Research, and academician A. Boyarchuk, chairman of the USSR Academy of Sciences' Astronomical Council, reported on the capabilities of the Soviet space-rocket complex "Energiya" (which was used to place the reusable spacecraft "Buran" into orbit) for creating large astronomy systems in interplanetary space.

The new "Energiya"—"Buran" space team will make it possible to have a giant optical telescope with a mirror 10 meters in diameter beyond the limits of the Earth, for example.

Nikolay Kardashev pointed out still another dazzling possibility which employment of Soviet launch-rockets of new types opens up, namely creation of a so-called space radiointerferometer. If two or several radio antennas which are sufficiently large are assembled in space and then taken to points hundreds of millions of kilometers apart (if one is placed in the orbit of Earth and the other near Jupiter, for example), this system of radio telescopes will have a resolving power of millionths of a second of arc.

The appearance of this new-generation space transport equipment has invigorated work which we are doing at the State Astronomy Institute on designing an observatory which will be on the moon.

Semenov Says Second Shuttle Flight Will Probably Be Unmanned

LD1602201989 Moscow World Service in English 1200 GMT 16 Feb 89

[Text] In most probability, the Soviet reusable spacecraft "Buran" will perform its next flight in an automatic mode again. This was said by the chief designer of the "Energiya- Buran" rocket space system, Yuriy Semenov. He expressed the belief that nothing will stand in the way of the new launch of the spacecraft, since it showed an excellent performance during its first mission. The program of the next flight should help bring out all the potentialities of the space vehicle. Yuriy Semenov did not rule out the possibility of the interaction between "Buran" and the orbital station "Mir," now manned by a Soviet crew.

Features of New Module to be Docked to 'Mir'

18660078 Moscow TRUD in Russian 27 Nov 88 p 3

[Article by V. Golovachev, special correspondent at the Flight Control Center]

[Extract] The 15th international space expedition has been launched from Baykonur.

Aleksandr Volkov, commander of the international crew, told about the upcoming mission in orbit shortly before it began:

"The expedition's program can be divided into three stages. The first will be joint work by a Soviet-French crew (the "Aragats" project). The second will be continuation of scientific research and experiments begun by previous expeditions. The third will be docking with a new module which will be sent to the orbiting complex next year, according to plans."

This second research unit which A. Volkov mentioned will add another 20 tons to the space residence (the "Mir"—"Kvant"—"Soyuz" complex now has a mass of about 43 tons). It is planned to send four specialized modules in all to "Mir" during the years immediately ahead. A huge and ramified complex with a mass of more than 130 tons will thus appear in orbit.

Plans call for docking the new module with "Mir" during the first four months of 1989. The module will have a spacious special compartment for egresses into open space, and also a lock chamber. Cosmonauts have long dreamed of this. At present, they are obliged to exit from the station through a hatch that is narrow and not very convenient. Tools and structures which are needed for work in space cannot be prepared or stowed in the station's cramped adapter module. They are usually placed in the neighboring living compartment of the spaceship, and a member of the crew subsequently drags the structures to the lock. This problem will finally be solved with the arrival of the second module.

The new module has still another interesting feature: in it will be a unit for movement of cosmonauts in open space. It is a self-contained space suit equipped with an individual propelling device which will enable cosmonauts to make flights outside the orbiting complex in the future. The task of cosmonauts Volkov, Krikalev and Polyakov for the time being will be a more local one: to reactivate the new equipment and check its operational fitness.

FTD/SNAP

'Mir-2' Space Station Under Construction

LD1203152189 Moscow in English to North America 0000 GMT 12 Mar 89

[Text] The Soviet Union is building another space research station of the 'Mir' type. The new space lab, 'Mir-2,' will have 12 mobile platforms mounted outside. They will house astro-physical equipment, saving much space inside the station. Future crews are likely to appreciate the advantages of the new design concept; to direct telescope to the earth or any other celestial body, they won't have to change the altitude of the station. This design concept was earlier used in the Vega unmanned space probe that studied Halley's Comet and it proved justified.

UDC 629.7

Motion of Gravitationally Oriented Satellite With Hysteresis Rods in Polar Orbit Plane

18650051a Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 5, Sep-Oct 88 (manuscript received 10 Nov 86) pp 654-668

[Article by V. A. Sarychev, V. I. Penkov, M. Yu. Ovchinnikov and A. D. German]

[Abstract] One of the principal difficulties in an analysis of satellite dynamics is the choice of an adequate hysteresis model. A comparison of the results of mathematical modeling of hysteresis within the framework of a refined model and the results of experiments with magnetic reversal in real rods revealed their satisfactory agreement. The refined model makes it possible, by numerical integration of the equations of satellite motion, to make an analysis of transient processes and to produce the steady motion of a satellite. However, it is difficult to select the parameters of the rods and satellite ensuring a minimal time of the transient process with a stipulated amplitude of steady motion within the framework of such a refined model. This is due to the great expenditures of computer time and the absence of simple expressions relating the parameters of the rod and satellite and the characteristics of motion. In this article it is shown that simplified hysteresis models of the parallelogram type are invaluable for ascertaining such relations. The correctness of the conclusions drawn on the basis of the derived relations can be checked using the refined model. This article describes the simplified model in detail. This model reflects the principal property of hysteresis: the dependence (of the Coulomb friction type) of magnetic reversal of the rod on the rate of change of the reversed field. Using the model a study is made of small oscillations of a triaxial gravitationally oriented satellite. It is shown that the scattering of energy of its characteristic oscillations occurs in the hysteresis rods during their magnetic reversal in the geomagnetic field. Depending on the orientation of the rods in the body of the satellite different laws of decrease in the amplitude of the oscillations are obtained. The necessary number of rods is determined on the basis of the condition of a minimum of the disturbances from the geomagnetic field and their orientation is determined from the condition of a maximum effectiveness of damping. Figures 5; references 21: 13 Russian, 8 Western.

UDC 629.197.2

Nonlinear Oscillations of System of Two Bodies Joined by Flexible Rod in Central Force Field

18660051b Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 5, Sep-Oct 88 (manuscript received 8 Jan 86) pp 669-674

[Article by V. I. Gulyayev, V. L. Koshkin, P. P. Lizunov and N. N. Prudenko]

[Abstract] In a system of two bodies connected by a flexible inextensible rod, a study is made of oscillations relative to their center of mass, which is moving in an elliptical Keplerian orbit. Periodic solutions of the equations of motion are written using the method of continuation of the solution in a parameter proposed by V. I. Gulyayev et al. in "Nonlinear Oscillations of a System of Two Bodies Relative to Their Center of Mass in an Elliptical Orbit," (KOSMICH. ISSLED., Vol 22, No 2, p 165, 1984), which serves as a basis for this continuing research on the problem. The influence of the reduced mass of the system and the rigidity of the connecting body of the rod on the stability and form of relative motion are investigated. In the range of examined

dynamic and rigidity parameters the motion of the carrying body differs little from the motion of the equimoment system of a solid body. A change in system mass exerts a considerable influence on the stability and form of motion of the carrying and carried bodies. A change in rigidity of the rod connecting the two bodies of the system exerts a substantial influence only on the form of motion of the carried body and in the range of the selected values of the parameters exerts little influence on motion of the carrying body. Figures 5; references 7 (Russian).

UDC 629.197.2

Analysis of Satellite Autonomous Navigation in Sighting of Unknown Surface Landmarks

18660051c Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 5, Sep-Oct 88 (manuscript received 30 Jan 87) pp 689-698

[Article by V. V. Ivashkin and L. I. Zadykhina]

[Abstract] The parameters of autonomous navigation of a spacecraft based on optical-television tracking of landmarks on a planetary surface and in a planetary atmosphere are analyzed. The direction of the line of sight of a landmark from aboard a spacecraft in an inertial coordinate system is determined in the course of such tracking. The case examined involves the optical sighting of stars and unknown surface landmarks, measurements of the angles between the directions from the spacecraft to stars and landmarks and the subsequent processing of these measurements for determining the orbital elements. The accuracy in determining the position of an artificial earth satellite during its motion in a near-circular orbit is analyzed. Its dependence on a number of basic navigation factors (number of landmarks, duration of measurement session, position of landmarks relative to the orbital plane, number of navigation revolutions, flight altitude) is investigated. The features of a navigation algorithm are presented. The admissible deviations of the initial values of the orbital elements from their precise values are investigated using this algorithm. The analysis shows that optical measurements with stars and unknown landmarks can be used in constructing an autonomous navigation system, making possible a quite reliable and precise determination of the parameters of spacecraft motion for a wide range of satellite orbits. Figures 5; references 21: 18 Russian, 3 Western.

UDC 629.191

Dynamics of Space Vehicle With Direct Active Control of Gravitational Stabilizer

18660051d Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 5, Sep-Oct 88 (manuscript received 2 Jun 86) pp 699-708

[Article by Ye. M. Potapenko]

[Abstract] In an earlier study (IZV. AN SSSR: MTT, No 1, pp 22-30, 1985) the author examined a system for orientation and stabilization of a spacecraft with a controllable gravitational stabilizer and auxiliary actuating mechanisms. This research is continued by examination of the possibilities of active control of a gravitational stabilizer without auxiliary actuating mechanisms. Such a system has been studied in the past, and it was demonstrated that it is completely controllable when no allowances are made for elasticity. The objective of this study was therefore an investigation of the influence of elasticity of a gravitational stabilizer on the dynamics of a spacecraft and also optimization of the system with respect to degree of stability and accuracy. Equations of motion of the spacecraft are written which take into account an arbitrary but finite number of tones of elastic oscillations of such a controllable gravitational stabilizer. A dynamic regulator is used in optimizing a system for control of orientation and stabilization of a spacecraft with allowance for the first tone of elastic oscillations. The direct Lyapunov method is used in demonstrating the asymptotic stability of the tones of elastic oscillations not taken into account. Figure 1; references 8 (Russian).

UDC 629.7

Research on Effect of Jet and Thermal Emissions of Electric Propulsion System on Space Vehicle Solar Cells

18660051e Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 5, Sep-Oct 88 (manuscript received 23 Mar 87) pp 796-798

[Article by S. N. Askhabov, D. P. Grdlichko, A. I. Kozlov, V. A. Koloskov, A. B. Petrov and V. P. Khodnenko]

[Abstract] A study was made to determine the resistance of panels of solar cells during prolonged exposure to the jet and thermal emissions of an electric propulsion system (two models of a stationary plasma engine were used in this research). Prior to placement of the panels of solar cells to be tested in a vacuum chamber, measurements were made of the structure of the jet and the thermal emissions of the stationary plasma engines in the range of discharge powers 0.4-25 kW. This background work made it possible to ascertain the relative positioning of the engines and solar cells in the chamber for simulating real operating conditions of these systems on a spacecraft. Several variants of the experiment were carried out. It was found that heating of the surface of the solar cells was associated for the most part with ion bombardment in the case of low-power electric propulsion systems, but the situation changes radically for powerful engines, making it necessary to take into account not only the relative role of thermal emissions, but also their radiation pattern. The results reliably represent the process of degeneration of the protective cover of the photoconverters and structural elements of the solar cells by the ion flux for sun-synchronous orbits (about 600 km) or lower orbits, but do not give a clear answer with respect to the influence of the effect of the jet on the optical characteristics of solar cells in a

geostationary orbit (about 36, 000 km), because of the considerable difference between ambient pressures in the chamber and in orbit. Data on the spatial structure of the jet and emissions of the stationary plasma engines made it possible to select an arrangement of solar cells and electric propulsion systems on a spacecraft ensuring prolonged joint operation of these systems. Figures 2; references: 1 Russian, 1 Western.

Optical System of Cosmos-1989 Described

PM1201114989 Moscow PRAVDA in Russian
12 Jan 89 Second Edition p 1

[Article by V. Grishmanovskiy, winner of Lenin and State Prizes and deputy scientific leader of the USSR Main Administration for the Creation and Utilization of Space Technology and Space Instrument Making Research Institute: "'Etalon' Launch; Cosmos-1989; Our Commentary"]

[Excerpts] All major mechanical changes taking place on earth, in near-earth space, and inside the earth are of considerable scientific and social interest because it is they that give rise to catastrophic phenomena—earthquakes, volcanic eruptions, tidal waves. [passage omitted]

Whereas in the early sixties satellite geodesy's main objective was merely to determine the position of the satellite in space and fixed points on the earth's surface in a regional system of coordinates, the accuracy of the determination of these has now reached such a high order that it has become possible to detect, with the aid of laser range-finding, very slight (1-2 cm per year) changes in the position of points on the earth and in the paramaters of the gravitational field. Moreover, with satellite observations the movement of the earth's belts can be determined with considerably greater accurancy compared with traditional astronomical methods. In connection with the need for the high-precision determination of the coordinates of various points and space installations within a unified geocentric system, an international service began operating in 1988 for the regular, prompt determination of the parameters of the earth's rotation. [passage omitted]

So what does the "Etalon" ("Cosmos-1989") passive space apparatus consist of?

It consists of a spherical hollow shell approximately 1.3 meters in diameter containing a balancing mechanism serving to colocate the satellite's center of mass with its geometrical center. Its external surface is covered with more than 2,000 optical light-reflective prisms made of fused quartz glass in the shape of a trihedral pyramids cut in a specific manner from cubes of quartz. The chief property of this unique optical element is the ability to precisely reflect back on themselves light emissions striking the entrant facet an angle. Thus, the "Etalon" passive space apparatus is a spherical light-reflective system that, while in orbit, reflects in the direction of the transmitter no matter what the angle of the satellite's position virtually all the laser emissions striking the satellite when surface stations are performing range-finding surveys.

Laser stations coordinated by the USSR Academy of Sciences Astronomical Council and also space communication centers' stations will be used for the surveys.

Commentary on Foreign Aerospace Plane Projects

18660083 Moscow KRASNAYA ZVEZDA in Russian
8 Dec 88 p 3

[Article by A. Shikov, engineer, under the rubric "Military and Technical Review"; "'Space Shuttle'—What's the Next Step: On the Wing in Space—'HOTOL,' 'Sanger,' and Others"]

[Text] So, the twenty-seventh in a series of flights of American reusable spacecraft has taken place. The flight was governed by a purely military mission—the Western press made that known to the world. As reported by the NEW YORK TIMES, the astronauts were to use the long mechanical arm to remove a unique spy satellite (its cost is estimated at $500 million) from the Atlantis cargo bay and "suspend" it in orbit, and then they were to conduct a series of experiments associated with space-based reconnaissance. According to that same newspaper, in the year to come the Pentagon plans to conduct, for its own needs, two more launches of Space Shuttle craft and seven launches of Titan rockets.

That, you might say, is today. But what about tomorrow? Specialists at the Langley Research Center (in Virginia) feel that after the year 2000 it will be necessary to develop transport systems that are more effective and more economical than the Space Shuttle.

At present, various concepts of a new generation of aerospace vehicles—concepts created in an "evolutionary" and a "revolutionary" type of development of equipment—are being proposed. The concepts for vehicles of the first type call for the development of new designs based on the experience garnered in the operation of launch vehicles that are disposable and Space Shuttle-type space systems. Those vehicles have liquid rocket engines and can make a vertical takeoff and a horizontal landing. The concepts associated with the second type of vehicle are oriented toward the creation of promising aerospace planes that are launched and landed horizontally and have powerful combined propulsion systems with air-breathing jet engines.

Foreign experts say that craft are also needed for deep space and for flight to other planets, and that the Shuttles can serve as prototypes for them. But near space—in low orbits—must also be developed. And here it would apparently be more economical to use aerospace planes.

The foreign press has noted that the Challenger disaster, which occurred two years ago, prompted work on the creation of the completely new so-called transatmosphere plane (TAP). Research on this project was entrusted to specialists of the division of aviation systems under the command of the U.S.A.F. As the journal AVIATION WEEK AND SPACE TECHNOLOGY stresses, this vehicle must be capable of taking off from military airfields and going into space; its versatility must consist of conducting reconnaissance, airborne offensive operations, strategic defense, and even isolation of combat actions.

According to the journal INTERNATIONAL DEFENSE REVIEW, the TAP aerospace plane, unlike the existing Space Shuttle, must be capable of descending from orbit into the denser layers of the atmosphere, changing its trajectory of motion, performing complex flying maneuvers, and then returning to space, but to a different orbit.

The TAP program, the foreign press emphasizes, which even until quite recently was so popular in the United States, is now virtually frozen. Its concepts, however, and certain design solutions have, in full measure, found reflection in the NASP project—the creaton of a national aerospace plane. The model being planned has already been named the X-30. The operations associated with this, the foreign press notes, are being financed primarily by the Defense Department, with the National Aeronautics and Space Administration (NASA) carrying 20-30 percent of the expenditures.

The external appearance of the X-30 has not yet been finalized. The basic model consists of a "wing-fuselage" configuration. At present, however, three other variations are being studied: a conical configuration, with a wing and without it; a "flying wing" configuration; and a wedge-shaped or tapered configuration with a round fuselage and slanted [otklonennyye] wing surfaces. Each variation has its pluses and its minuses.

A multitude of problems have yet to be solved. AVIATION WEEK AND SPACE TECHNOLOGY, for example, reports that extremely high temperatures will develop in the nose fairing and on the leading edges of the wing surfaces: on the order of 2,750°C and 1,925°C, respectively. In connection with this, besides intermetallic composite materials, which are guaranteed to withstand temperatures of up to only 980°C, so-called active cooling methods for aircraft structures are being developed. Specifically, the use of cooling tubes and convection and evaporation devices is being suggested.

Designs indicate that the X-30 will be quite comparable to the Boeing 727 in size, but comparable to the F-15 fighter in dry weight. Carrying a small payload, the X-30, it is expected, will expend nearly 45 tons of hydrogen in flight. By comparison, a spacecraft like the Space Shuttle, with a payload of nearly 30 tons, "uses" more than 2,000 tons of liquid oxygen and nearly 450 tons of liquid hydrogen.

The Western press reports that the final decision on the construction of the X-30 aerospace plane will be made in 1990, at which time the testing program will also be decided upon. Flight tests of the airplane will begin in 1994-95.

There are also other projects. In the United States, virtually all large aerospace firms are trying to devise variations of similar kinds of aircraft—single-, two-, and three-stage designs. The firm Lockheed, for example, tells the journal AIRFORCE that it is studying the design of a rather large (61.5 m in length), two-seater aerospace plane that is capable of taking off like an airplane and placing a payload of up to 9 tons into orbit, as well as being able to make prolonged flights in the atmosphere at subsonic speeds.

In 1988, in fact, Boeing reported that it had done research in a program involving a small spacecraft launched from the "back" of a carrying airplane that was a refitted Boeing 747 jumbo jet. This aspect of the firm's activity is not being publicized much at this time, but there is every reason to believe that the work the firm started is continuing.

In England, researchers are actively pursuing studies of the potential associated with the development of the single-stage aerospace plane HOTOL, which would take off and land horizontally. Specifically, British Aerospace (BAe) and Rolls Royce are working up their own renditions.

The dimensions of this aerospace vehicle, according to the foreign press, are close to those of the supersonic Concord passenger airplane. According to preliminary designs, the length of the vehicle is 76 m; its wing span, 20 m; its takeoff weight, nearly 200 tons; its weight in orbit, 48 tons; and its landing weight, 84 tons. The routine duration of a single flight is 12 hours.

As noted at the last airshow at Le Bourget, work on the combined engine for HOTOL has already reached the bench-test stage. Full-scale development of the spacecraft is slated to begin in 1991, and flight tests are scheduled to begin in 1998.

In order to attract attention to the project, BAe declared at one of the aviation and space exhibitions the possibility of using the vehicle as a passenger transport. According to the calculations of the firm, a flight from London to Sidney would take about 45 minutes. The firm is planning to place a pressurized passenger compartment in the payload compartment of the airplane. The passengers would experience weightlessness during the ballistic trajectory of the flight. The advertising brochures even indicate the price of a ticket for a flight along this air route—$50,000.

The design of a two-stage aerospace vehicle, the Sanger 2, is being worked out in West Germany. The first stage is a hypersonic speed plane for flying in the atmosphere;

it is equipped with six rocket-turbine engines. Its design is expected to be maximally modified with a hypersonic transport airplane. The second stage, the press reports, can be the reusable, winged, piloted orbital stage, HORUS, or the unmanned cargo stage, CARGUS, based on the base rocket unit of the Arianne launch vehicle.

In a word, there is no shortage of ideas. Similar projects exist in Japan and in France. For now, however, they are far from being realized. The problems are many, the main one being, as foreign reviewers stress, financial. But even the results that have already been produced, the reviewers conclude, represent achievements in themselves and can produces advances in many industries that are far from space, including military hardware and arms.

Commentary on French 'Hermes' Project

18660084 Moscow KRASNAYA ZVEZDA in Russian 14 Dec 88 p 3

[Article by M. Rebrov, colonel, under the rubric "A Discussion at the Request of the Readers": "'Buran' and 'Hermes': A Flight Into the Future"; the first paragraph is a letter written to KRASNAYA ZVEZDA by Senior Lt. G. Pavlov]

[Text] *The press has reported that the program of Soviet-French cooperation in space calls for working out the "compatibility of the Hermes vehicles and Mir-type orbital stations." What kind of a vehicle is the Hermes? Is it similar to our Buran? And when can such flights begin?*

Senior Lt. G. Pavlov

The farther man goes into deep space and the larger and more daring his projects become, the clearer becomes the vital necessity for international efforts in mastering the boundless sea of the Universe. We know today how expensive experiments and research in space are. But we can imagine rather accurately the yield that they promise. Especially when they are done together, through the efforts of many countries.

It goes without saying that the leading world powers who were the first to take to the road of using space in the interests of science and practical matters have their own national programs. It is natural. Others are imitating them. The motives are quite varied. One administrator of the French National Center for Space Research (CNES), Frederic D'Allest, declared to journalists: "Our programs are smaller than the Soviet or American programs, but implementing them will nevertheless create the conditions that member-countries of the European Space Agency need in order to acquire certain experience and autonomy in the field of space research."

Such projects include the engineering and development of the Arianne-5 launch vehicle (the payload it can deliver to orbits of various altitudes ranges from 6 to 20 tons), the Hermes spacecraft, and participation in the American program for developing an orbital space station (the code name of the project is Columbus). The lion's share of the allocations within the framework of the European Space Agency is borne by France and FRG.

The current CNES president, academician Jacques Lou Lions, in telling of France's plans for space research, places special stress on the importance of cooperation with the Soviet Union, which has a great deal of experience, powerful booster rockets, and large orbital stations and can develop unique automated laboratories, organizing cooperation among the scientists of many countries. Moreover, the scientist noted, the project involving the Hermes spacecraft can be completed only by 1997.

That schedule is conditional. French specialists visiting the Soviet Union (those who attended the launch of Soyuz TM-7 at Baykonur and were in the Flight Control Center during the docking and during jointly performed experiments) named another date—1999—and explained that it is because of the complexity of the problems to be solved and the absence of "skills and technologies." Such skills and technologies involve certain aspects aerodynamics and aerothermodynamics, software, thermal protection, on-board power systems, and developments of reliable control equipment and thermal regulation systems. We are talking about "six critical areas" that were officially registered at the meeting of the CNES and the European Space Agency in October 1985.

The date (1999), however, requires further elucidation. Research in the area of the development of an aerospace plane began in France in the early 1980s. A configuration was worked out for a two-stage aircraft with a vertical takeoff, launched by the Arianne-5 rocket. The work went slowly both because of insufficient funding and because of the "toughness of the nut that had to be cracked," wrote the French newspaper MONDE. The suggestion was made to create a quarter-scale mock-up of Hermes (the Maia [Mayya] project), in order to facilitate and accelerate the preliminary research. But every new solution was taken up with great caution.

"We are going to have to beat our brains out if we want Hermes to take off within an acceptable schedule," D'Allest assured his colleagues, and he suggested that the industrial groups that would receive the most important orders be determined as soon as possible. It was at that point that Aerospatial [Aerospasyal] and Avion Marsalle Dasso-Brege Aviation [Avon Marsal Dasso-Brege aviasyen] were singled out as among the leading groups.

And so France took the difficult road in order to place into near-Earth orbit, at an altitude of 400 km and an inclination of 28.5°, an aerospace craft weighing 9-11 tons. It is assumed that the payload delivered into space will weigh 5.5 tons in the unmanned model and 4.5 tons if the craft is piloted by a three-man crew.

The length of the vehicle is 17.9 m; its height, 5.1 m; its wing span, 10.2 m (with an angle of sweep of 74°). The flight deck of Hermes is reminiscent of the flight deck of an A-820 passenger airplane (25 cubic meters of space). The service life of the craft is preliminarily estimated to be 30 flights.

And although Hermes will begin flying only in another ten years, it pales seriously by comparison with Buran. The overall length of the reusable Soviet craft is 36.4 m; on the tarmac it stands 16.5 m high; its wing span is nearly 24 m. The flight deck can hold a crew of 2-4 people with 6 passengers. The pressurized cabin has more than 70 cubic meters of space. Buran's cargo bay is the size of a spacious railroad car and can carry a payload of up to 80 tons. At 105 tons, the launch weight of our craft is 10 times that of the French craft. The altitude of the reference orbit of Buran is 250 km; its working orbit is 450 km. If need be, it can move up to an altitude of 800-1,000 km.

Of course, there is no comparison between the performance characteristics of the launch vehicles. The Arianne-5, as already noted, is capable of placing a payload of up to 6 tons into a high orbit and three times as much—up to 20 tons—into a low orbit. The all-purpose Energiya rocket and space transport system, on the other hand, can deliver various sizes of payloads weighing more than 100 tons into space.

Every country has its own potential, its own experience, its own plans. The Soviet Union sees the enormous prospects that space research holds for meeting purely earth-bound needs. And if a broad international collaboration were effected in that area, it would not be Europe alone that would come out ahead because of it, but all of mankind, too. One would like to believe that the leaders of the leading Western countries have enough common sense to stop any attempts at militarization of space and transform it into an arena of broad collaboration in the interests of peace and progress.

As for the compatibility of the Hermes vehicles with Mir-type orbital stations, there is more than enough potential here, and the prospects for collaboration in the area of space are quite glowing. The present Soviet-French space flight confirms that.

Space Monitoring System To Be Element of Ecological Information Center

18660104 Moscow KOMSOMOLSKAYA PRAVDA in Russian 16 Jan 89 p 1

[Article by Ye. Samotesov, deputy head of an administration of the USSR State Committee for Nature Conservation]

[Text] An enlarged meeting of the board of the State Committee for Nature Conservation (Goskompriroda) has been held with the participation of representatives of the USSR State Planning Committee, the USSR Ministry of Geology, the USSR State Forestry Committee, the Cosmonaut Training Center imeni Gagarin, and other ministries and agencies which monitor the condition of the natural environment.

Proceeding on the basis of principles for implementation of a unified scientific-technical policy in the field of nature conservation and efficient nature management, it is deemed expedient to create a unified ecological monitoring information system consisting of an All-Union State Ecological Information System (VGEIS) and a Global Space system of Ecological Monitoring.

An automated information system which USSR Goskompriroda is developing is to become the organizational-technical basis of the VGEIS. USSR Goskompriroda's all-Union scientific research center "Ekologiya" (ecology) has been assigned the functions of chief organization for creation of the VGEIS.

UDC 551.582:551.521+629.78

Key Aspects of Research on Earth's Radiation Budget

18660049a Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 5, Sep-Oct 88 (manuscript received 8 Dec 87) pp 3-10

[Article by G. I. Marchuk, K. Ya. Kondratyev and V. V. Kozoderov, Limnology Institute, USSR Academy of Sciences, Leningrad; Computational Mathematics Department, USSR Academy of Sciences, Moscow]

[Abstract] Key aspects of research on the Earth's radiation budget (ERB) were analyzed: the importance of data on the ERB for understanding the patterns of climate, their use for evaluations of the role of albedo and cloud-radiation feedbacks. The requirements on data on the ERB are defined. Direct measurements of components of the ERB must be made using wide-angle detectors of the integral fluxes of long- and short-wave radiation. Data must be obtained on the spectral distribution of the ERB, being significant for identifying anthropogenic effects on the ERB. In connection with solution of the tasks to be solved by the World Climate Program (WCP), it is of the utmost importance to develop systems of combined observations (especially from satellites) of radiation parameters. Validation of requirements on the errors and spatial-temporal resolution of observations plays an important role. The key elements in the strategy for measuring the solar constant (SC) are: continuous, highly precise satellite measurements of the SC with overlap of series of observations using different instruments (satellites); regular calibrations of on-board instrumentation relative to a standard with an absolute error not greater than 0.05 percent. Under these conditions it is possible to ensure multiyear SC observations with an error of less than 0.1 percent. Definite requirements are imposed on errors in the mean monthly fluxes of short-wave outgoing radiation and long-wave outgoing radiation. The error in retrieving the radiation budget of the Earth's surface must not exceed 10 W/m^2 with a spatial (temporal) resolution of 500 km (1 month). A higher spatial resolution (100 km) is necessary for regional research, and a higher temporal resolution is required in the tropics. Simultaneous observations of a broad range of parameters characterizing cloud temperature, temperature and wind fields, humidity, aerosol and gas composition of the atmosphere are of very great importance. The objective of diagnostic research is an analysis of the spatial-temporal variability of the ERB in the tropics and in the extratropical latitudes, energy transformation, diurnal variation of the ERB and cloud cover and influence of aerosol on the ERB. Research for which ERB data are particularly important includes: study of atmospheric energetics on regional and global scales, evaluations of heat transport by the ocean, evaluations of the role of SC variability, checking of schemes for the parametrization of radiation processes and comparison of the computed and observed ERB fields. These and other related matters are discussed in various degrees of detail. References 26: 7 Russian, 19 Western.

UDC 551.46.0:629.78

Determination of Spectrum of Energy-Bearing Surface Waves From Solar Glitter Image

18660049b Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 5, Sep-Oct 88 (manuscript received)

[Article by A. N. Bolshakov, V. M. Burdyugov, S. A. Grodskiy and V. N. Kudryavtsev, Marine Hydrophysics Institute, Ukrainian Academy of Sciences, Sevastopol]

[Abstract] The problem of determining the spatial spectrum of sea surface elevations from the spectrum of brightness variations of its images has been repeatedly discussed in the literature, but research has been limited to an analysis of images outside the solar glitter zone. However, brightness variations in the glitter caused by surface waves are large and are easily registered. The problem of retrieving the spatial spectrum of the rise of surface waves on the basis of a spatial spectral analysis of image brightness in the glitter zone was therefore investigated. A model of the image of surface waves in the glitter zone was formulated, and the formulas necessary for applying this model were derived. The parameters of the brightness trend in the image sector being processed

are used in scaling the spectrum of brightness variations to the spectrum of elevations. Two criteria are defined for choosing an image sector for processing: the fragment must be situated near the region of "inversion of contrasts" and be optimal for observing a wave system. An example of spectrum retrieval from an aerial photograph is given. Figures 3; references 9: 3 Russian, 6 Western.

UDC 551.501

Possibilities of Joint Determination of Characteristics of Ozone and Aerosol Content on Basis of Polarization Measurements of Outgoing Atmospheric UV Radiation

18660049c Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 5, Sep-Oct 88 (manuscript received 6 Apr 87) pp 27-34

[Article by M. S. Biryulina and Yu. M. Timofeyev, Leningrad State University imeni A. A. Zhdanov]

[Abstract] A study was made of the possibility of using polarization measurements of outgoing UV radiation for the purpose of increasing the accuracy in retrieval of the vertical profile and total content of ozone and in joint determination of the characteristics of ozone and aerosol content. The idea was developed earlier by Morgenthaler (APPL. OPT., 1984, Vol 25, No 7, pp 990-997), but no correct evaluations were made of its information yield or accuracy. It was found that under conditions of a highly turbid atmosphere there is a considerable decrease in the informativeness of measurements of outgoing UV radiation relative to ozone content parameters. In order to minimize the influence of aerosol it is desirable to measure the perpendicular component of scattered radiation, which is only slightly dependent on the aerosol state of the atmosphere. Measurements of the two polarization components of outgoing scattered radiation make possible simultaneous retrieval of the vertical profiles of ozone content and aerosol concentration with a significant increase in accuracy in comparison with traditional measurements. The proposed approach makes it possible to obtain a considerable quantity of information on the aerosol state of the stratosphere. Figures 2; references 18: 10 Russian, 8 Western.

UDC 551.509.338

Determining Clear-Sky Planetary Albedo

18660049d Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 5, Sep-Oct 88 (manuscript received 8 Jun 87) pp 44-49

[Article by K. Ya. Kondratyev, V. V. Kozoderov, S. Kh. Keevallik and O. Yu. Kyarner, Limnology Institute, USSR Academy of Sciences, Leningrad; Computational Mathematics Department, USSR Academy of Sciences, Moscow; Astrophysics and Atmospheric Physics Institute, Estonian Academy of Sciences, Tyravere]

[Abstract] A method for determining clear-sky planetary albedo on the basis of radiation measurements from space is described. The method is based on the combination of the minimal values of the measured planetary albedo and theoretical computations, as a point of departure using the known climatic values of albedo of the Earth's surface. The mean monthly clear-sky albedo values were determined for squares with areas of 0.25 million square kilometers using measurements from the Nimbus-7 satellite. It is shown that data for the deserts and semideserts of Africa, the Arabian Peninsula and Australia can best be processed by a lengthening of the time series. For tropical forested areas, however, where cloud cover is considerable, and for the ocean the lengthening of the time series must be supplemented by broadening of the considered region. Over uniform regions with a seasonal snow cover, as well as over savannas, where moist and dry seasons occur, it is best to broaden the considered region by the joining of squares with an identical type of surface. Over remaining land regions it is necessary to use special formulas for computing albedo of the Earth-atmosphere system from albedo of the Earth's surface. These formulas are essential in processing data for coastal squares. The method takes into account the specific observational conditions better than computation of system albedo on the basis of climatic data on the Earth's surface albedo. To some degree the method also eliminates errors caused by conversion from albedo of the Earth's surface to planetary albedo. Figures 3; references 10: 4 Russian, 6 Western.

UDC 551.521.14:631.174.26

Determining Relative Area Occupied by Sown Crops From Spectrometric Measurement Data

18660049e Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 5, Sep-Oct 88 (manuscript received 17 Apr 87) pp 71-75

[Article by D. N. Mishev and R. Kh. Kyncheva, Central Space Research Laboratory, Bulgarian Academy of Sciences, Sofia]

[Abstract] Known methods for evaluating the condition of agricultural fields are based on an analysis of the spectral reflectivity of the soil-vegetation system. However, these methods are flawed by a number of shortcomings which can lead to considerable errors, already pointed out in the literature. Accordingly, a new method is proposed for determining the relative area occupied by vegetation. The parameters which must be determined are defined and an approximate formula is proposed for computing the projective cover. The application of the method, which eliminates the earlier sources of error, is illustrated in the example of a typical chernozem-winter wheat system in the milky ripeness phase. The measurements were made in the spectral range 0.4-0.8 μm using a 20-channel field spectrometer. The method gives an accuracy adequate for practical purposes, requires a lesser number of measurements and is applicable in cases when the research is carried out in some time interval

and to a high degree is invariant relative to ambient conditions, making it more universal. Figures 1; references 11: 8 Russian, 3 Western.

UDC 551.521.2

Comparison of Computed and Measured Spectra of Outgoing Radiation in the 15m Carbon Dioxide Band

18660049f Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 5, Sep-Oct 88 (manuscript received 23 Jun 87) pp 76-80)

[Article by D. Spenkuch, W. Dehler and Yu. M. Timofeyev, Leningrad State University imeni A. A. Zhdanov; Main Meteorological Observatory, GDR Meteorological Service, Potsdam]

[Abstract] The results of comparisons of the measured and computed quantities of outgoing radiation in the carbon dioxide 15μm band are analyzed. In general, it was found that a considerable contribution to the detected mismatches between measured and computed spectra is made by errors in stipulating aerological information and the spatial-temporal mismatching of satellite and aerological measurements. It is shown that the use of a more modern radiation model of the atmosphere than employed earlier and the careful selection of situations for which there is high-quality aerological information and good spatial-temporal agreement of aerological and satellite measurements resulted in a two- or threefold reduction in mismatches between the computed and measured outgoing radiation spectra. For example, in the spectral region 668.7- 700.9 cm^{-1}, in which outgoing radiation is formed in the stratosphere and upper troposphere, an analysis of 12 cases of computed and measured values did not reveal systematic mismatches and the standard deviations insignificantly exceeded the level of measurement errors. There is a good agreement between theory and experiment except for the center of the band in the region near 13.91 μm. For the band wing the computed values exceed the experimental values. Figure 1, references 8: 6 Russian, 2 Western.

UDC 535.361.2+528.813

Brightness of the Halo Around a Laser Beam in Vegetation Cover

18660049g Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 5, Sep-Oct 88 (manuscript received 13 May 87) pp 87-93

[Article by A. E. Kuusk, Astrophysics and Atmospheric Physics Institute, Estonian Academy of Sciences, Tyravere]

[Abstract] Detailed phytometric measurements in test sectors are needed in developing remote methods for investigating the vegetation cover from satellites. Such measurements have been extremely time- consuming, dictating development of a new approach. One such method is active laser sounding of the vegetation cover, both at the surface and from low-flying aircraft. Since the structural characteristics of the vegetation cover determine the brightness structure of the halo around a laser beam, the inverse problem can be solved: the measured brightness field can be used in determining the structural parameters of the vegetation cover. Solution of the direct problem (description of halo brightness as a function of the optical and structural characteristics of the vegetation cover) can be simplified by selecting the laser radiation wavelength in the red or blue parts of the spectrum where the reflection and transmission coefficients for green plants are less than 10 percent. Then halo brightness around the laser beam will be determined for the most part by double scattering. The problem is simulated by examining a case when a narrow vertical beam of radiation (laser) probes a plane-parellel medium consisting of thin plates. This research made it possible to formulate a quantitative theory of formation of the halo around the beam in vegetation cover with an elliptical leaf orientation. Examples are given showing that the halo brightness profile is sensitive to changes in the structural parameters of the vegetation cover: orientation of leaves, density of leaf area and also the optical parameters of leaves and the soil. Figures 3; references 11: 7 Russian, 4 Western.

UDC 502.3:629.78

Tomographic Approach to Identification of Lineaments on Aerospace Images

18660049h Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 5, Sep-Oct 88 (manuscript received 4 Feb 87) pp 99-103

A. S. Alekseyev, I. G. Kazantsev and V. P. Pyatkin, Computer Center, Siberian Department, USSR Academy of Sciences, Novosibirsk]

[Abstract] The automated identification of lineaments on aerospace images of different scales is extremely important, but attempts to use gradient-type operators, statistical differentiation and various filtering algorithms have failed to yield materials suitable for further analysis. None of the methods take into account or use such highly important specific characteristics of lineaments as linearity and extent. Spatial differentiation and high-frequency filtering also both lead to noise in the processed images. Accordingly, a tomographic approach is proposed for detecting lineaments on aerospace images which is free of the mentioned shortcomings. The method applies the criterion of optimality (information yield) of projections. Software for identifying lineaments is written for use on the SM-4-"Omega" computer system, which has interactive and graphics capabilities. Figure 1, references 8 (Russian).

UDC 528.7+629.78

Principal Results of Research on Theme 'Aerospace Research on Natural Resources of Siberia' (Tenth Anniversary of the Science Coordination Council, 1977-1987)

18660049i Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 5, Sep-Oct 88 (manuscript received 13 Oct 87) pp 111-115

[Article by L. K. Zyatkova, Geology and Geophysics Institute, Siberian Department, USSR Academy of Sciences, Novosibirsk]

[Abstract] During the period 1977-1987 there have been five sessions of the Science Coordination Council of the Presidium of the Siberian Department, USSR Academy of Sciences, on "Aerospace Research on Natural Resources." The fifth, most recent session (April 1987) was devoted to discussion of timely problems in use of aerospace information in solving economic and scientific research problems formulated under the "Sibir" program, with emphasis on the detection of areas promising for the discovery of oil and gas, research on ecological equilibrium in the biosphere and multifaceted automated processing of images for solving a variety of economic problems. The article gives the results of research on three themes: "Use of Remote Methods for Study of Natural Complexes (Geological-Geographical Research)," "Use of Remote Methods for Studying Biological Resources" and "Principles and Methods for Automated Processing of Aerospace Information." The decade of implementation of this program has resulted in publication of 341 articles, 30 collections of articles and monographs. In particular, the results have been summarized in the monographic collection of articles "Aerospace Research on Siberian Natural Resources," published in four books in 1987-1988. The results of this research revealed that the difficult problems of efficient use of natural resources can be solved only with a multifaceted approach to study of natural features in individual key sectors where, in addition to subsatellite and surface observations, it is necessary to interpret space photos with the use of computers and other devices for the identification of natural features on the basis of their optical characteristics. In solving economic problems, space survey materials are most effectively used by large teams of subunits with different specialties that are working within unified research areas. References: 25 Russian.

UDC 502.3:528.7:629.78

International Aerospace Experiment 'Kursk-85'

18660049j Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 5, Sep-Oct 88 pp 116-118

[Article by L. N. Vasilyev]

[Abstract] The international aerospace experiment "Kursk-85" was carried out during the period 10-30 June 1985 with the participation of Bulgarian, Hungarian, Vietnamese, East German, Polish, Soviet and Czech specialists. The objective was the development of a method for determining the condition and dynamics of agricultural crops for yield prediction models and also study of the structure of land use on the basis of aerospace information. The experiment was carried out in two sectors of the Kursk Aerospace Test Range, both characterized by a similar type of agricultural use and the same range of cultivated crops. The experimental program included the following: 1) determination of the structure of land use; 2) determination of the correlation between the parameters of physical fields and characteristics of the vegetation cover; 3) determination of the distribution and reserves of soil moisture and its temporal changes; 4) detection of erosional processes. The multilevel experiment was carried out using the "Salyut-7" station, "Meteor" satellite and AN-30, Tu-134 and An-2 aircraft laboratories, accompanied by surface observations. The experiment made it possible to develop a method for studying the dynamics of agricultural geosystems on the basis of remote sensing data. For example, space and aircraft measurements are interpreted through the biogeophysical characteristics of the vegetation cover by numerical modeling of the radiation regime. The determination of the condition of crops and the growth process is based on application of the theory of nonlinear dynamic systems. A procedure was developed for interpreting the phase trajectories of development of vegetation, obtained from remote measurements, jointly with soil-geomorphological conditions, on the basis of a conjugate analysis in real geographical space. A procedure was developed for systems analysis of the spatial structures of geosystems on the basis of a classification of land use with allowance for the dynamic characteristics of vegetation, soil- geomorphological and microclimatic conditions, including evaluation of elementary geosystems. A number of objectives for further research were defined. The international team of specialists has prepared articles on the results of this research for publication in this journal.

UDC 551.46.0:551.5:629.78

'Atlantika-87' Experiment

18660049k Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 5, Sep-Oct 88 pp 118-119

[Article by L. A. Vedeshin, V. A. Urdenko and Yu. V. Terekhin]

[Abstract] The "Atlantika-87" experiment was carried out during the period May-August 1987 in a test range in the western tropical part of the Atlantic Ocean using measurements made from the "Mir" orbital station, satellites of the "Meteor" and NOAA series and the "Akademik Vernadskiy" scientific research ship. The principal objectives were a determination of the hydrophysical and biological characteristics of the water medium on the basis of the functional and empirical relationships between them and the parameters of the radiation ascending from the ocean in the visible part of the spectrum and retrieval of the ocean surface temperature field from images in the IR range received from satellites. Specialists from the Marine Hydrophysics Institute, Biophysics Institute and Biology of the Southern Seas Institute participated in shipboard work. Satellite images were received and processed. Facsimile pressure pattern charts were received, and optical, thermal and biological investigations of test range waters and

meteorological observations were made using submerged and noncontact instruments. Measurements of the vertical profiles of the light attenuation index, spectral brightness coefficient, integral characteristics of the light field and concentration of phytoplankton pigments in the layer 0-200 m were made. The water color index was measured during daytime. All these data were used in plotting maps of the distribution of transparency and water color over the test range, the content of chlorophyll "a," ocean surface temperature (OST), radiation temperature of the research region, total solar radiation, radiation balance and cloud cover distribution over the studied waters. A two-channel method was developed for computing OST in breaks in the cloud cover using data from satellite images. Shipboard temperature and radiation measurements were made in computing the dispersion of errors on OST maps plotted on the basis of satellite images of the ocean. Data from temperature sounding of the upper 15-m layer at 200 drift stations gave an estimate of the influence of the diurnal variation of OST and the dynamics of the diurnal heating of the upper quasihomogeneous layer under different hydrometeorological conditions on the accuracy in determining temperature by the employed method.

UDC 551.583:341.12

Earth's Radiation Budget Observations: Data Processing Problems

18660092a Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 6, Nov-Dec 88 (manuscript received 8 Dec 87) pp 3-19

[Article by K. Ya. Kondratyev and V. V. Kozoderov, Limnology Institute, USSR Academy of Sciences, Leningrad; Computational Mathematics Department, USSR Academy of Sciences, Moscow]

[Abstract] The problems involved in processing of satellite observations of the Earth's radiation budget have been discussed in a series of recent monographs. This article supplements this material and reviews and critiques the most recent literature (for the most part American) on this subject. The review is a detailed discussion of validation of schemes for transformation from measured signals to physical parameters: determination of the integral fluxes of outgoing short-wave and long-wave radiation on the basis of measurements of the spectral intensity of outgoing radiation; averaging of data in time with allowance for diurnal variation; filtering of the drift of instrument response and ensuring homogeneous sets of data; assimilation of data on the Earth's radiation budget. References 31: 6 Russian, 25 Western.

UDC 528.813:551.5

Retrieval of Albedo of Broken Cloud Cover From Results of Satellite Observations

18660092b Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 6, Nov-Dec 88 (manuscript received 7 Jan 87) pp 20-26

[Article by G. A. Titov and T. B. Zhuravleva, Atmospheric Optics Institute, Siberian Department, USSR Academy of Sciences, Tomsk]

[Abstract] The angular distribution of the intensity and albedo of a cloud field consisting of clouds of finite horizontal extent differ considerably from the corresponding characteristics of a homogeneous plane-parallel layer. In order to eliminate ambiguities arising in the interpretation of satellite data a correlation must be established between the mean measured energy characteristic and the mean albedo. Such a correlation has now been established in a case when the horizontal inhomogeneity of the cloud cover is attributable only to random geometry (broken cloud cover). A model was formulated for this purpose. The results of computations for wide-angle detectors indicate that the assumption of Lambertian scattering of solar radiation by the cloud cover in the case of cumulus clouds results in both an exaggeration and understatement of mean albedo, and in the case of stratiform clouds, a systematic exaggeration of mean albedo by about 10- 20 percent. If in the retrieval of mean albedo the effects associated with the finite horizontal extent of cumulus clouds are neglected, the error in determining the albedo of cumulus clouds is tens of percent, increasing with cloud cover tenths. Neglecting of the horizontal inhomogeneity of cloud fields results in a substantial error in determining the albedo of the atmosphere-Earth's surface system. The use of narrow-angle detectors when retrieving mean albedo when using satellite observational data for cumulus clouds has a number of advantages since it makes it possible to obtain the necessary statistics for determining the mean spatially measured energy characteristic and to determine the mean albedo using a simple formula. Figures 6; references 11: 10 Russian, 1 Western.

UDC 551.466.8:629.78

Research on Surface Manifestations of Short-Period Internal Waves in Ocean by Remote Methods

18660092c Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 6, Nov-Dec 88 (manuscript received 12 Dec 86, after revision 21 Dec 87) pp 27-32

[Article by V. Ye. Gershenzon, Space Research Institute, USSR Academy of Sciences, Moscow]

[Abstract] The registry of surface manifestations of short-period internal waves (IW) in the ocean is examined with respect to the requirements which must be satisfied by remote sensing apparatus (both the instrument and its carrier) in order to ensure optimal discrimination (by spectral analysis methods) of a useful signal against a background of noise associated with the presence of low-frequency surface waves. The study was based on data collected off Kamchatka Peninsula in 1984-1985 using a radiometric survey at 2 cm from a drifting ship as an example of frequency analysis and a photographic survey from an aircraft as an example of spatial analysis. It was found that whereas when using time frequencies the spacing of signals caused by the contributions of IW and SW is 1 ½ orders of magnitude, when using spatial frequencies the signal spacing is only by a factor of 2. Under such conditions high-frequency

filtering carried out for the purpose of discriminating the useful low-frequency signal caused by IW is considerably simpler in the time variant. Examination of typical dispersion characteristics for the useful signal and noise clearly indicate that preference must be given to time analysis and the optimal carrier is an aerospace system because it makes it possible to obtain an ocean image at adequately short time intervals. Figures 4; references: 7 Russian.

UDC 551.24:(528.77+629.78):550.814

Digital Processing of Lineament Network for Analysis of Regional Tectonic Structures of Western Himalayas in India

18660092d Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 6, Nov-Dec 88 (manuscript received 21 Mar 88) pp 41-50

[Article by D. K. Misra, V. M. Moralev and O. G. Sheremet, Wadna Himalayan Geology Institute, Dechratun, India; Lithosphere Institute, USSR Academy of Sciences, Moscow]

[Abstract] Space photographs were used within the framework of an Soviet-Indian cooperation program in studying tectonic movements in the Western Himalayas. The studied region is located between 30 and 36°N and 74 and 79°25'E. The only suitable method for studying an area with such diverse structural elements was a quantitative analysis of the complex lineament networks. The employed method for the digital processing of the lineament networks interpreted on space photographs (described in detail), consisting of linear, arcuate and annular elements, was entirely effective since it made it possible to obtain additional new geological information on the existence and position of deep tectonically active zones evidently corresponding to buried recent faults. Photointerpretation also made it possible to detect new, earlier unknown lineaments and annular structures in the Western Himalayas region whose nature remains partially unclear due to the inadequacy of surface information. Two large transverse tectonic zones were detected which are zones of increased seismic danger in the Western Himalayas. These zones, like other structural elements interpreted on space photographs, must be taken into account in the seismic regionalization of the territory and in the choice of sites for the construction of large engineering structures. This method for the digital processing of lineament networks can unquestionably be used in more detailed neotectonic research and in seismic regionalization for individual regions of the Himalayas and other collisional covering-folded systems when using medium- or high-resolution space or aerial photographs. Figures 6; references 12: 8 Russian, 4 Western.

UDC 551.46.0:629.78

Radiation Models of Mesotrophic and Eutrophic Water Bodies

18660092e Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 6, Nov-Dec 88 (manuscript received 25 May 87) pp 72-82

[Article by A. A. Gitelson and F. Siladi, Hydrochemical Institute, Rostov-na-Donu; Water Management Center, Hungarian People's Republic, Budapest]

[Abstract] The radiation parameters invariant relative to remote sensing apparatus, survey conditions and seasonal variations of species composition of phytoplankton were determined and radiation models of mesotropic and eutrophic water bodies, relating their spectral brightness coefficients and their hydrobiological and hydrochemical indices, were constructed. The spectral characteristics of radiation ascending from the water and the factors governing them were determined on the basis of a great volume of synchronously measured spectrometric, hydrochemical and hydrobiological data. Criteria for interpreting optically active components in spectrometric information were found. These served as a basis for constructing radiation models which relate the water quality indices and remotely sensed characteristics, the spectral brightness coefficients for different wavelengths in the visible range, stable in time for each of the investigated water bodies (from year to year, in different hydrological phases and states of development of hydrobionts). The parameters of the models are dependent on the microphysical properties and the type of hydrosol, the species composition of phytoplankton, etc. and differ for different water bodies. The developed models are a priori information for interpreting multiband space videoinformation. The models were checked in different water bodies with a concentration of mineral suspended matter from 3 to 40 mg/liter and chlorophyll "a" from 1 to 400 mg^3. This information was used in developing a method for remote estimation of the concentrations of optically active components in mesotrophic and eutrophic water bodies ensuring estimates of the concentration of chlorophyll "a" with a standard error not greater than 3 mg/m^3 and for mineral suspended matter not more than 4 mg/liter. The method makes it possible to carry out remote speedy measurements of reference data necessary for interpreting space information. Figures 4; references 24: 20 Russian, 4 Western.

UDC 551.46.0:629.78

Processing Method and Results of Microwave-Radiometric Investigations of Earth From 'Intercosmos-20' and 'Intercosmos-21' Satellites

18660092f Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 6, Nov-Dec 88 (manuscript received 4 Nov 86) pp 88-94

[Article by A. B. Akvilonova, M. S. Krylova, B. G. Kutuza, V. P. Savorskiy and M. T. Smirnov, Radio Engineering and Electronics Institute, USSR Academy of Sciences, Moscow]

[Abstract] Prolonged trajectory measurements of terrestrial radiothermal emission carried out using a microwave radiometer carried aboard the "Intercosmos-20" and "Intercosmos-21" made it possible to investigate some characteristics of the fields of radiation and geophysical parameters. The scale of temporal variabillity of

the investigated fields was about one month. The processing of the measurements made it possible to discriminate zones of falling of precipitation over the ocean. A special set of algorithms and programs (including for the synthesis of fields on the basis of trajectory measurements) was prepared for processing the measurements. Some of the programs can be used in processing future experiments. Estimates of the polarization of continental radiation indicated that at 2.25 cm the polarization coefficient for measurements in desert regions was 8-10 percent. The measurement results are illustrated by estimates of ocean surface temperature and a map of polarization of radiation for the African continent. Figures 4; references: 7 Russian.

UDC 528.852:681.391.837

Improvement of Multiband Color Images by Enhancement of Local Contrasts

18660092g Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 6, Nov-Dec 88 (manuscript received 10 Jun 86) pp 95-99

[Article by P. A. Chochia, Data Transmission Problems Institute, USSR Academy of Sciences, Moscow]

[Abstract] Multiband color aerospace photographs in many cases have inadequately high clarity and contrast. Enhancement of such images can be achieved by digital processing which upgrades the local brightness and color differences. There are relatively few processing methods for such color images (these are reviewed) and they all lead to destruction of the color balance of the processed image. Accordingly, a new rectification method is proposed which makes it possible to enhance image clarity while the retaining the mean color and brightness hues of extended image sectors. The described method is in many respects similar to the method for enhancing local contrasts of black-and-white images described earlier by the author in ISSLED. ZEMLI IZ KOSMOSA, No 6, pp 66-78, 1985. Modifications of that method are outlined. It considerably increases the possibility of subsequent visual analysis and interpretation of videoinformation. As a result of such processing local brightness and color differences appear which are virtually undetectable on the initial image. Experiments demonstrated that the enhancement of local contrasts, using formulas derived in this article, can be used successfully both in an analysis of multiband aerospace videoinformation and in many other cases when data can be represented in the form of a color image. Figures 3; references 7: 3 Russian, 4 Western.

UDC 551.5

Determining Periods of Contact Between Artificial Earth Satellites and Stipulated Sectors of Earth's Surface

18660092h Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 6, Nov-Dec 88 (manuscript received 16 Jul 87) pp 100-103

[Article by A. Ye. Melkobrodov and D. V. Moiseyev]

[Abstract] An approach is outlined for determining the periods of time of presence of an artificial earth satellite over regions of the Earth's surface whose coordinates and configuration are stipulated. A method is proposed for solving this problem in the case of unperturbed motion of an artificial earth satellite independently of the type and parameters of its orbit. The method is oriented on application in automated computer complexes and can be used in the early stages of the planning of artificial earth satellites, their elements and surface complexes. The approach provides for the use of a special coordinate system and the representation of the artificial satellite trajectory in the form of a set of parametric dependencies, being second-degree polynomials. In the computation plan the problem is reduced to solution of a set of quadratic equations written in a definite way. The method was applied using a YeS-1040 computer in the form of a program in PL/1 language. An example of solution of the problem is given. References: 5 Russian.

'Cosmos-1990' Launched To Study Resources, Seismic Zones

LD1301094089 Moscow TASS International Service in Russian 0925 GMT 13 Jan 89

[Text] Moscow, 13 Jan (TASS)—The Cosmos-1990 artificial earth satellite was launched in the USSR on Thursday by a Soyuz carrier rocket. It is intended for the continuation of study of the Earth's natural resources in the interests of various branches of the national economy of the USSR and international cooperation. The flight program also envisions photography of seismically active regions of the country, including the territory of Armenia, with the aim of studying seismotectonic conditions in the interests of industrial and civilian construction.

The satellite was put into orbit with the parameters:

—initial period of revolution: 88.7 minutes;
—maximum distance from the surface of the earth: 259 kilometers;
—minimum distance from the surface of the earth: 192 kilometers;
—orbital inclination 82.6 degrees.

The apparatus is working normally.

Satellites Launched for Civil Navigation, Spacecraft Tracking

LD1101083489 Moscow TASS in English 0830 GMT 11 Jan 89

[Text] Moscow January 11 TASS—Three satellites in the Cosmos series, the Cosmos-1987, Cosmos-1988 and Cosmos-1989, were launched by the Proton booster rocket in the Soviet Union on Tuesday.

The Cosmos-1987 and Cosmos-1988 satellites are intended to test the components and equipment of a space navigation system being developed with a view to determining the positions of Soviet civil aviation planes, merchant vessels and fishing boats.

The principle purpose of the Cosmos-1989 satellite is to secure the reception of data to raise the accuracy of determination and prediction of the movement of spacecraft as well as for geodetic and geophysical research.

The satellites were put into an orbit close to a circular one with the following parameters:

Initial orbital period—11 hours, 15 minutes,

The distance from the earth's surface—19,140 kilometres,

Orbital inclination—65 degrees.

The onboard equipment is functioning normally.

'Gorizont' Communications Satellite Launched

LD2701085889 Moscow TASS International Service in Russian 0842 GMT 27 Jan 89

[Text] Moscow, 27 Jan (TASS)—Another "Gorizont" communications satellite was launched by a "Proton" carrier rocket in the USSR on Thursday in accordance with the program for development of communications systems and television broadcasting with the use of artificial earth satellites.

The satellite has been put in near-stationary orbit, with the initial parameters as follows:

distance from the earth's surface—36,506 km;

period of revolution around the earth—24 hours and 33 minutes;

orbit inclination—1.3 degrees.

The satellite's on-board equipment is functioning normally. The control and measurements system is guiding the satellite. The satellite's communications and television equipment will be used in accordance with a preset program.

'Cosmos-2000' Satellite Launched 10 Feb

LD1102093289 Moscow TASS in English 0922 GMT 11 Feb 89

[Text] Moscow February 11 TASS—The Cosmos-2000 satellite was launched by a Soyuz booster rocket in the Soviet Union on Friday [10 February]. The satellite carries scientific equipment for a continuation of the exploration of the earth's natural resources for the benefit of various branches of the national economy and international cooperation.

The flight programme also provides for space photography of the central part of Antarctica for the mapping of the continent's difficult of access areas.

The satellite was put into an orbit with the following parameters:

Initial orbital period—88.8 minutes,

The maximum distance from the earth's surface—275 km,

The minimum distance from the earth's surface—191 km,

And orbital inclination—82.3 degrees.

The satellite also carries a radio system for precision measurement of orbit elements and a radiotelemetric system to transmit back to earth the data on the operation of instruments and scientific equipment.

The onboard equipment is functioning normally.

The incoming information is being transmitted to the State Research Center Priroda of the USSR Central Board of Geodesy and Mapping for processing and utilisation.

To Photograph Antarctica

LD1102094189 Moscow TASS in English 0925 GMT 11 Feb 89

[Text] Moscow February 11 TASS—The Soviet Cosmos-2000 satellite, launched Friday, will take pictures of the central region of Antarctica. The plane of the satellite's orbit, close to polar one (running across the earth's poles), has been chosen for this purpose.

"To put a spacecraft into such an orbit is a technically complex task. This is why not a single spacecraft yet photographed those areas," Yuriy Kiyenko, general director of the State Research and Production Centre Priroda told a TASS correspondent.

"The inclination of the satellite's orbit is 83 degrees. This means that it is somewhat shifted away from the earth's poles. However, methods which have been worked out for oblique photography will make it possible for the cameras of the filming equipment to cover the entire surface of the south polar continent".

Kiyenko said the photography of Antarctica, the area of which is 14 million square kilometres, from orbit will be approximately 98.8 per cent cheaper than air photography. Pictures to be taken by the Cosmos-2000 will make it possible to carry out a precise mapping of the central part of Antarctica for the first time.

Unique data on the ice cover, on the outcrops of rocks, the formation of glaciers and icebergs will be also gleaned. New data will be possibly obtained on the process of the formation of the ozone "hole" over the area.

Along with the survey of the ice continent, the satellite's flight programme comprises the study of natural resources, the ecological situation, seismically dangerous zones, and photography for the mapping of various regions of the Soviet Union.

The first satellite in the Cosmos series was launched in March 1962. Many spacecraft of the series were designed to study the natural resources of the earth. However, some of them accomplished other tasks. For example, medico- biological experiments were performed on board the Cosmos- 782, -936, -1129, -1887 and others.

The Cosmos-1500 carried out the radio scanning of terrestrial surface and the world ocean area and the resultant data were utilised for the piloting of ships in the Arctic Ocean and Arctic seas.

Cosmos satellites also tested in practice a space navigation system which ensures navigation in any spot of the world ocean. The Cosmos-1374, -1445, -1517 and -1614 maneuvering satellites were the first Soviet aerospace vehicles which tested heat protective covering for the Buran reusable spaceship.

The Cosmos-1990 launched in January this year, along with other functions, is photographing seismotectonic structures of Armenia. This is necesary for planning new construction in the republic's northern areas which were ravaged by a heavy earthquake in December.

Soviet space pictures are notable for high quality, resolution which has not been surpassed anywhere in the world, geometric accuracy and spectral characteristics. Suffice it to say that terrestrial surface features the size of about five metres are discernible on the pictures whereas the resolving power of pictures taken by the systems of the American Landsat satellites, for example, is 30-40 metres. Pictures taken from Soviet satellites are now purchased by more than 40 firms from the United States, Japan, France, the Federal Republic of Germany, Canada and other countries.

'Molniya-1' Satellite Launched 15 February

LD1602081989 Moscow TASS International Service in Russian 0740 GMT 16 Feb 89

[Text] Moscow, 16 Feb (TASS)—The latest earth satellite "Molniya-1" was launched on Wednesday [15 February] by a "Molniya" booster. The satellite is intended to provide for the use of the long-distance telephone and telegraph radio communication system, as well as for broadcasting USSR Central Television program to points on the "Orbita" network.

The satellite has been placed in a high elliptical orbit with the following parameters: apogee 38,937 km in the northern hemisphere and perigee 486 km in the southern hemisphere. Period of revolution is 11 hours 38 minutes and orbital inclination 62.5 degrees.

Communication sessions through the "Molniya-1" satellite will take place in accordance with the scheduled program.

'Tsiklon' Launches 'Meteor-2' Weather Satellite

LD2802133789 Moscow TASS International Service in Russian 1255 GMT 28 Feb 89

[Text] Moscow, 28 Feb (TASS)—The "Tsiklon" rocket launcher today launched the latest meteorological earth satellite in the Soviet Union, "Meteor-2". The satellite has been placed in an orbit with the following parameters: initial period of revolution—104.1 minutes; apogee—974 kilometres; perigee—951 kilometers; orbital inclination—82.5 degrees.

Sets of apparatus have been installed onboard the satellite to obtain global images of cloud layers and the underlying surface in the visible and infrared ranges of the spectrum for storage and for direct transmission, as well as sets of radiometric apparatus for constant observation of the streams of penetrating radiation in circumterrestrial space. The equipment on board the satellite is working normally.

Shatalov Discusses Past, Future Missions, Cost Benefits From Space Program

PM2701161189 Moscow TRUD in Russian
26 Jan 89 p 4

[Interview with Lieutenant General of Aviation V.A. Shatalov, chief of the Cosmonaut Training Center, by V. Golovachev under the rubric "Readers Conduct the Interview": "Why Are We Going Into Space?"; date, place not given; questions provided by TRUD readers]

[Text] A. Rodionov, Leningrad: The first flight of the Soviet Buran shuttle was the event of last year. TRUD reported (27 November last year) that "in accordance with the test program, it was planned to carry out the shuttle's second flight in automatic mode. But, following Buran's brilliant debut, certain specialists are proposing a reduction in the program of unmanned flights by the shuttle." Has the question of Buran's second flight been decided? What is your personal opinion—should it be manned or unmanned? To put the question more broadly: Why do we trust automatic machines more than man on spaceflights, and why do we endeavor to allocate him a secondary role?

[Shatalov] I will begin by answering the last question. This is a rather old discussion: Who should have priority on a spaceflight—man or an automatic machine. The arguments have already died down, and there is nothing to discuss, for it is all clear: It is invalid to contrast them. A person has his functions, while machines have theirs. Today it is impossible to imagine a flight by a transport craft, work on an orbiting station, or progress in cosmonautics at all without modern high-speed computers and all the very complex "smart" technology. But it is still the cosmonaut who is master on board the craft. He is not a "passive observer," but precisely the pilot and researcher who creatively resolves the complex problems that frequently arise on a flight.

In the past there was a clash of two positions, two approaches to manned flights. Certain designers stubbornly believed that technology must be trusted more than people. A serious blow was dealt to these views back in 1965 at the time of the unplanned landing of Voskhod-2, when the craft was unable to return to earth from the planned revolution because of faults in the automatic equipment. And it was only by using the manual control system that the crew guided the craft onto the descent path.

Later, too, cosmonauts repeatedly found a way out in very complex critical situations. It is sufficient to recall, for example, how in June 1985 Vladimir Dzhanibekov and Viktor Savinykh approached in manual control mode the uncontrolled and unoriented Salyut-7 station, which had lost radio contact, flew around it, executed a meticulously precise and very complex docking maneuver, and repaired the systems that had gone out of commission. In general, so many repair operations have been carried out in space recently that a separate book could be written about this. So life and space practice have confirmed that automatic systems must not be "absolutized."

Today's concept—the optimum combination of work by automatic machines with creative human activity—determines the development of cosmonautics in our country.

As for Buran's next flight, I believe that it could be a manned one (after comprehensive training, of course). However, there are, of course, other opinions. As far as I know, the final decision has not yet been made. First we must conduct a careful investigation of the craft that has returned from space...

V. Timofeyev, Voronezh: How many people will there be in the crew on Buran's first manned flight? What is the largest possible crew on board a shuttle? Who is training to fly on Buran?

[Shatalov] Two cosmonauts will evidently conduct test flights of Buran before it goes into regular mode. Subsequently, there could be four people in the crew manning Buran. And for individual tasks requiring the participation of different kinds of researchers, as many as 10 people could fly on board Buran.

The cabin is divided into two compartments—upper and lower. The total volume is 73 cubic meters (more than seven times that of the three-seater "Soyuz TM"). There is also a payload compartment: It is approximately 5 meters in diameter and more than 18 meters long.

Now about those who are being trained to fly in Buran. TRUD has already reported their names. They are experienced test pilots—I. Volk (group leader), V. Zabolotskiy, R. Stankyavichyus, U. Sultanov, M. Tolboyev, S. Tresvyatskiy, and Yu. Sheffer.

K. Khasanov, Oktyabrskiy, Bashkir ASSR: The newspapers have written that reserve landing strips will be constructed for Buran-type shuttles. Where precisely? Will Buran be our only specimen, or are other shuttles planned?

[Shatalov] One reserve landing strip for shuttles will be completed in the region of Simferopol, and another in the eastern part of the country. Of course, the present Buran will not be our only space shuttle. For example, a second craft is now being assembled in the Baykonur Cosmodrome's assembly and testing block...

D. Shumilin, Minsk: How many flights can a shuttle make? How long can it stay in space orbit?

[Shatalov] The shuttle is designed for 100 spaceflights. Its stay in orbit depends on the program. At the first stage, up to 7 days; subsequently, up to 1 month.

T. Grishchenko, Kiev: What is the fate of the Salyut-7 orbiting station?

[Shatalov] It has been decided to leave this station, which has completed its working life, in space in order to conduct service life tests. This is important to designers. For the Mir has largely been manufactured from the same materials as Salyut-7. Therefore, it would be interesting to learn how long these materials retain their properties and how they change under the impact of cosmic rays, meteorites, the vacuum, the tremendous temperature gradient... We must check the thermal and meteorite protection, and so forth. After the service life tests have been completed, Salyut-7 will either be returned to earth by Buran or sunk in the ocean after descending from orbit.

V. Krivtsov (Ryazan), A. Orlyanskaya (Kerch), Ya. Merdukh (Neteshin, Khmelnitskiy Oblast), and others—in all, this subject was broached in 67 letters: We seem, at last, to be starting to count money in earnest. We have abandoned the fabulously expensive diversion of rivers (which could have done irreparable harm), we want the defense industry to work more for the needs of the national economy, we are cutting back the Army and armaments, and so forth. This question arises in this connection: Is it not time to cut appropriations for space exploration?

[Shatalov] Generally speaking, these questions are wrongly addressed. Our center trains cosmonauts and crews who, possessing highly professional qualities, must ensure the fulfillment of space programs and of complex tasks that arise with regard to station repairs, and so forth. Nevertheless, I will express my opinion on the problems broached.

Space exploration is of tremendous significance to the development of science, and economic progress is also impossible without it. The latest space equipment and technology are reference points for our entire industry.

Only let us not touch on these very important aspects but see what space exploration gives us directly for the practical needs of the national economy.

First, the satellite communications system. Television broadcasting and multichannel long-distance telephone and telegraph communications embrace practically the entire population of the country (93 percent). By the year 2000, 7 out of every 10 messages carried by all communications channels will be transmitted via space. But if we were to lay down cable communications? The cost would be fantastic...

Second, the Tsikada satellite navigation system, which serves ships in the world's oceans. It provides great savings.

Now weather satellites. The use of meteorological information from space ensures annual savings to the national economy of up to R500-700 million.

Concerning such a very important area as study of the earth's natural environment and resources, photographs from space combined with aerial and traditional geological exploration methods and geophysical and geochemical research make it possible more quickly and more cheaply to determine promising areas to look for minerals. For example, a comprehensive analysis of data from an investigation of the Kola peninsula, the Verkhoyansk range, and the region around the Sea of Okhotsk revealed a number of promising territories to prospect for ore deposits. Judge for yourselves: What is more profitable—to extract our own metal or purchase it abroad?

Only from space did we detect circular structures created by ancient volcanoes in the Okhotsk-Chukotka Zone (this covers thousands of kilometers). We have begun looking for minerals in remote desert regions: rare metals in the Far East, copper in the region of the Baykal-Amur Main Railroad, tin in Yakutia.... In its time the space phototectonic map of the Aral and Caspian region was a real sensation. It was then that the Astrakhan oil- and gas-bearing region was selected for priority development. The prognosis was brilliantly confirmed.

Efficient use can be made of space information in agriculture and forestry, by hydroelectric power, construction, and transportation workers.... Space photography has a real, palpable effect in mapmaking. Information from space is extremely necessary to fishermen. The detection of accumulations of plankton and shoals of fish makes it possible to seek and catch fish more efficiently, to save fuel on ships, and so forth.

In all, more than 1,000 organizations of many ministries and departments in our country use space information today. The savings exceed R1 billion a year. This completely repays the expenditure on spaceflights (not on the creation of equipment, though).

As we see, there is a considerable practical return on space research. But I must say that **those readers are right who ask this question: Why is such insignificant use made of spaceflights to resolve urgent national economic tasks?** Speaking of manned flights, for example, the return on them for our economy could, in my view, be immeasurably greater. It was long ago proved that under weightless conditions in orbit it is possible to obtain invaluable medical preparations and unique crystalline materials, to carry out manufacturing processes that cannot be achieved on earth, and so forth.

Experiments have been finalized, but what now? **On a permanently manned orbiting station it would be possible to organize semi-industrial production of medicines, crystals, semiconductors, and many other things. The technical possibility for this already exists. But for some reason no one is interested in it.** Perhaps we have not yet

awakened after the "stagnation hibernation"? Industrial firms in the West are fighting vigorously to lease a certain capacity on board the [U.S.] shuttle, a fight for every gram of payload stowed aboard the craft. Their aim is to open up space for industry as quickly as possible. Unfortunately, such tendencies are very weak in our country. We have a big shortfall here. And readers are quite right to note this substantial shortcoming. It is clear that **an abnormal situation has taken shape and must be changed as quickly as possible.**

D. Lisin, Nizhniy Tagil: Highly developed countries (they do not throw money to the wind) do not indulge in such costly space experiments—probably this is no coincidence?

[Shatalov] Why do you say they do not? The Americans, for example, intend to construct a large orbiting station that will cost approximately $25 billion to create. And take the new proposals recently put forward by NASA scientists. The creation of a permanently manned base on the moon by the year 2005, the possibility of a crew flying to Mars by the year 2007 (one estimate of the cost of a manned mission is $190 billion), the creation of a colony on Mars by the year 2015... The Hermes shuttle is being built by France, the FRG, and a number of other countries within the framework of the European Space Agency. Britain and Japan are developing their own shuttles.

The "Soyuzkarta" Foreign Trade Association receives orders for space photography from various countries. A single color photograph with negative costs an average of $1,000. So I ask: Should we abandon work in a sphere in which we hold the lead?

D. Bortsov, Novosibirsk: What is the program for manned flights in 1989? [Shatalov] A. Volkov, S. Krikalev, and V. Polyakov are currently on duty aboard the Mir. They will be relieved by another crew in April. A. Volkov, S. Krikalev, and V. Polyakov will return to earth 29 April. The new crew will work until the fall, when there will be another change of watch.

S. Markina, Yaroslavl: Are long flights—lasting 1 year, for example—necessary?

[Shatalov] If we seriously want to open up space, we cannot do without such flights.

A number of specialists consider work by space crews lasting 1 year to be the optimum. Others, however, are convinced that crews work most efficiently for 4-6 months. If we disregard superlong flights designed to study the effect of weightlessness and other space factors on the human organism, then orbital flights lasting no more than 6 months, with the possibility of a "shift overlap" ["peresmenka"] in orbit, should, in my view, be the norm.

At the same time, I believe it expedient to switch crews not over the space of a few days but over a longer period. It is a question of having both crews work together for a month or two and carry out the most difficult, intensive program during this period. During the remaining 3-4 months the one crew should tackle research, manufacturing processes, the unloading of Progress, and so forth. Thus, 2-3 expeditions could be carried out in the space of 1 year. And foreign cosmonauts could work on the station during those few months when two crews will be working simultaneously on the orbiting complex.

S. Grachev, Kursk: The newspapers have written that specialized modules will be dispatched to the Mir complex. When will this happen?

[Shatalov] There are plans for two modules to be launched and then docked with the complex this year. The designers want the interval between the docking of the first and second modules to be minimal. This is because an asymmetry will arise in the space complex when one of them docks, which will complicate control of it.

D. Krutoyarov, Tomsk: Ground services—controllers, designers—have recently been making quite a few mistakes. One of the two automatic interplanetary stations now flying toward Mars went out of commission because of an incorrect command. There were two malfunctions in a row when international crews returned last September and December; landing had to be deferred until emergency orbits... What accounts for this?

[Shatalov] The growing complexity of space programs demands special composure, attentiveness, and responsibility on the part of all involved in a spaceflight. Of cosmonauts, designers, scientists, and ground control services. Unfortunately, no one is insured against mistakes. Thus, what is needed is systems which will provide, for example, backup insurance and additional verification of the correctness of commands transmitted to space from earth.

The growing breadth and complexity of space programs, including the organization at the Mission Control Center of parallel work with other space objects (Buran and Fobos, for example), requires the involvement of a large number of young specialists in flight control. Maybe they have not all been trained adequately for such work. We have a rule at the Cosmonaut Training Center: Every specialist who deals with crews must receive the same training as the cosmonauts themselves. Only then can he be considered a real specialist.

V. Shurgot, Moscow: What international flights are planned in the future?

[Shatalov] An accord has been reached for a Soviet-Austrian spaceflight.

In an interview in the newspaper EXPRESS, the FRG minister of research and technology expressed the hope that the first joint Soviet-West German spaceflight will take place no later than 1991.

Talks are being held with Britain, Malaysia... The USSR Main Administration for the Creation and Utilization of Space Technology [Glavkosmos] is ready to receive applications from all countries to participate in flights on a commercial basis.

The French side wants month-long joint Soviet-French flights to be made once every 2 years. This has greatly heartened Michel Tognini, the standby for Jean-Louis Chretien, who recently returned from space. M. Tognini now has a real chance of going to an orbiting station in 1990 or early 1991.

[Golovachev] Incidentally, there is a question concerning the French cosmonaut. Zh. Tkacheva of Donetsk asks: "M. Tognini got married in Zvezdnyy Gorodok. Who is his wife, how old are they both, and where do they live—in Zvezdnyy or Paris?"

[Shatalov] Michel Tognini is 39. His wife, Yelena Vasilyevna Tognini (Chechina) works at the Cosmonaut Training Center as an instructor in physical culture and sport. She is 22. They now live in Zvezdnyy, but previously they had travelled to Paris.

D. Krivich, Lvov: I heard on the radio that an American (a singer, I think) wanted to go to the Mir station at his own expense, within the framework of a commercial flight. Will he fly?

[Shatalov] I personally did not like this option very much right from the start. We are not opening up space for the amusement of millionaires. But, nevertheless, there exist commercial rules announced by the USSR Glavkosmos. And so talks were conducted with the American, as agreed. The flight costs $10 million. He applied to the U.S. State Department and received permission. But when the deadline for signing the contract arrived, no signals were received from the singer. He had evidently undertaken all this only for publicity...

V. Molchanov, Tula: I am very interested in cosmonautics. I was told that a women's crew—S.Ye. Savitskaya, Ye.A. Ivanova, and Ye.I. Dobrokvashina—had been training to fly to an orbiting station. Nothing was reported about this. Who were their standbys?

[Shatalov] Yes, in 1984 it was decided to prepare a female crew to fly to the Salyut-7 orbiting station. The commander was to be S. Savitskaya, who had already made a spaceflight in July of that year. The crew also included engineer Ye. Ivanova and physician Ye. Dobrokvashina. Their standbys were A. Viktorenko, A. Aleksandrov, and V. Solovyev. Why a male crew? The answer is simple. Because the decision had been made much earlier that every crew must include one cosmonaut who has already made a flight. In the women's crew this was S. Savitskaya. But there was no female cosmonaut for a standby women's crew who had the experience of a flight and who was ready at the time for a new one. That is why the standbys were men. But after the birth of S. Savitskaya's baby the women's flight did not take place.

V. Petrovicheva, Ivanovo: Will women fly in space this year?

[Shatalov] No, such a flight is not planned. Women are not currently being trained at our center.

V. Korablev, Voronezh: Are our cosmonauts training for a moon shot?

[Shatalov] There is no such need at present. But it is impossible to imagine space exploration in the future without exploring the moon and setting up lunar bases there.

S. Trunova, Baku: Why is nothing heard about cosmonauts A. Zaytsev and A. Kaleri, who were reported earlier to be members of standby crews? How many cosmonauts are in the detachment now?

[Shatalov] A. Kaleri and A. Zaytsev are not undergoing training for medical reasons. Five crews are now preparing for future flights, and each one consists of two men: a commander and flight engineer. Ten people in all. Depending on the future, amplified flight program, researchers being trained in their own programs may later be included in the crews. The group training to fly the shuttle also has a special program (based on flight tests).

T. Spiridonov, Arkhangelsk: Are V. Savinykh, G. Grechko, A. Yeliseyev, V. Aksenov, and V. Bykovskiy training for new flights?

[Shatalov] No, they are not. V. Savinykh is now rector of the Moscow Institute of Engineers of Geodesy, Aerial Surveying, and Cartography. G. Grechko is working in an institute of the USSR Academy of Sciences. A. Yeliseyev is rector of the N.E. Bauman Moscow Higher Technical School. V. Aksenov is director of a scientific research institute. V. Bykovskiy is director of the House of Soviet Science and Culture in Berlin (GDR).

S. Orlov, Suoyarvi: I still remember with anguish the tragic demise of the first Soviet crew of an orbiting station—G. Dobrovolskiy, V. Volkov, and V. Patsayev. Everything connected with that flight is dear to history. Would it not be possible to name the cosmonauts who were in the standby crew?

[Shatalov] The thing is that G.T. Dobrovolskiy, V.N. Volkov, and V.I. Patsayev were members not of the first but of the second crew during training for the Soyuz-11

and Salyut orbital station flight. The first crew consisted of A.A. Leonov, V.N. Kubasov, and P.I. Kolodin (he now works at Mission Control Center). Physicians detected some changes in V.N. Kubasov at the cosmodrome (later all this passed, and 4 years later he participated together with Leonov in the joint Soviet-U.S. flight under the Apollo-Soyuz Experimental Flight program). But in 1971, when there were just a few days remaining until the launch of Soyuz-11, physicians at Baykonur grounded Kubasov. If one crew member is taken off a flight, this means that the entire crew cannot fly. The State Commission made the decision: The second crew—G. Dobrovolskiy, V. Volkov, and V. Patsayev—would go into space.

I remember how upset Leonov, Kubasov, and Kolodin were at being taken off the flight. But a truly dreadful blow still awaited us all, when our comrades died during their return to earth. Everyone took it unbearably hard at the time. But it was impossible to look at Kubasov, Leonov, and Kolodin with their darkened, pinched-looking faces, feeling deeply the death of cosmonauts with whom they had flight-trained and who had taken their places...

V. Trofimov, Chelyabinsk: How do you see the future of cosmonautics?

[Shatalov] The industrialization of space. Plants in orbit that will give people materials and medicines that are inaccessible on earth. Satellite information systems. High-capacity orbiting power stations...

I am also sure that there will be lunar settlements (with the aim of producing many rare materials from lunar rock for terrestrial needs and lunar bases) and interplanetary expeditions, and that secrets of nature will be discovered that will make man truly powerful and that will bring people considerable benefits....

Military Applications of 'Mir' Station Modules Denied

LD1801180189 Moscow TASS in English 1501 GMT 18 Jan 89

[Text] Moscow January 18 TASS—A new technological module for the Soviet long-term orbital complex "Mir" will be launched in the first six months of 1989, Aleksandr Dunayev, head of the Chief Administration for the Development and Use of Space Engineering for the Economy and Research (Glavkosmos), told a news conference today.

The news conference held at the press centre of the USSR Foreign Ministry was devoted to the space flight of Soviet Cosmonauts Vladimir Titov and Musa Manarov that lasted a year and work in orbit of a Soviet-French international crew. The module of additional equipment will enable the crew—Aleksandr Volkov, Sergey Krikalev and Valeriy Polyakov, now working on board the station, to obtain various samples of semiconductors in a greater volume than at present and also to obtain biological preparations.

Dwelling on questions of Soviet-French cooperation in outer space, Aleksandr Dunayev said that it will develop and gain momentum. And work will be conducted not only in the framework of scientific and technological cooperation, but also on a commercial basis. Manned flights on board the Soviet orbital station are planned to be made every two years within the next ten years.

A question about the book "Soviet Cosmonautics" brought out in the FRG was asked at the news conference. It is said, specifically, in that book that it will be possible to conduct work for military purposes with the use of modules that are planned to be linked up with "Mir" station in future. French cosmonaut Jean-Loup Chretien answered this question. "These words cannot be regarded otherwise than as a joke. I worked twice on board Soviet stations and can say with full responsibility that they are not meant for military purposes at all. Such statements also run counter to the overall policy of the USSR which declares for exclusively peaceful use of outer space", he said.

The future modules will enable people from different countries who are to work with Soviet cosmonauts on board the station to get convinced of the peaceful character of all the space programs of the Soviet Union, said Vladimir Shatalov, chief of the cosmonauts training center. Cosmonauts from 15 countries who already participated in joint programs got convinced of this. Vladimir Titov who was commander of a year-long expedition in space, said that quite possibly a representative of the FRG will be able to see for himself what the Soviet orbital complex is like and what equipment it carries.

Sagdeyev Continues to Work At IKI After Retiring As Director

LD1801180289 Moscow Domestic Service in Russian 1330 GMT 18 Jan 89

[Excerpts] There was a news conference in Moscow today for Soviet and foreign journalists. It was devoted to the results of the longest-ever space flight and the outcome of the second Soviet-French mission. We present a recording of this press conference.

[Begin recording] [passage omitted] [Unidentified journalist] Is it true that Academician Roald Sagdeyev has retired, and if so why? I mean from the post of director of the Institute of Space Research (IKI).

[A.I. Dunayev, head of the USSR Main Administration for the Development and use of Space Engineering for the Economy and Research] It is probably not news here. Academician Sagdeyev had been director of the Institute of Space Research for a long time and it was he who asked to be released from this post. There were elections.

Corresponding member Galeyev became director of the Institute of Space Research and Academician Sagdeyev is working in this institute, leading a large group of scientists who are working on systems analysis for space research. He has therefore not left active space work. [end recording]

Career of Chief Designer V. I. Kuznetsov

18660106 Moscow KRASNAYA ZVEZDA in Russian 7 Jan 89 p 4

[Article by Colonel M. Rebrov]

[Abstract] The full-page article traces the career of academician Viktor Ivanovich Kuznetsov, a chief designer of space-rocket control devices and a laureate of the Lenin and USSR State prizes.

While a student at a polytechnical institute, Kuznetsov developed an interest in aviation and joined a group, "Engineering Design and Structure of Aircraft", it is recalled. This group was organized by Professor A. F. Ioffe, dean of the engineering-physics school. After graduating from the institute, Kuznetsov became a senior engineer at a plant. He began to work on gyroscopes in 1938. He designed a fire-control stabilizer for cruisers and a bombsight, and the worked on complex problems of vertical-gyroscope theory and developed a ship gyroscope. During World War II, he took part in development and testing of a stabilization system for tank guns, a radio-controlled airplane and a sight for fighter aircraft.

Shortly after the war ended, Kuznetsov made the acquaintance of Sergey Pavlovich Korolev and other pioneers of space rocketry during a trip abroad to study German rocket equipment. Kuznetsov became a chief designer and head of a large group of developers in 1946, and he was among the six members of the Council of Chief Designers which went into operation shortly afterward, serving as the council's control-device specialist. He also headed a number of scientific and technical directions at a design bureau which eventually developed into a scientific and technical directions at a design bureau which eventually developed into a scientific production association. Work was done there on extremely precise and sensitive gyroscopic instruments, which furthered development of self-contained control systems.

Development and launching of the first Soviet satellite, the "Voskhod", "Soyuz" and "Buran" spaceships, the orbiting stations "Salyut" and "Mir", and the "Energiya" space rocket system are mentioned as some of the pioneer projects in which Kuznetsov took part. In a conversation, the designer shared personal recollections of a fatal accident which occurred during a rocket launching in October of 1960, and of conversations which he subsequently had with Brezhnev, who was sent to Baykonur in connection with this incident. It is recalled that the technical commission which Kuznetsov headed and other personnel of the space-launch complex were badgered persistently by Brezhnev, who was impatient for 'conclusions' in regard to the accident and was willing to accept even casual and superficial versions.

Kuznetsov hailed Soviet achievements in development of precision instruments, particularly g-load measuring devices which are installed on rockets. These instruments must measure forces with a precision as high as 10 to power minus 6—10 to power minus 8, it is noted.

A photograph of V. I. Kuznetsov is given.

U.S.-Soviet Cooperation on Lunar, Planetary Projects

18660105 Vilnius SOVETSKAYA LITVA in Russian 20 Jan 89 p 3

[Article by Yuriy Surkov, doctor of physical-mathematical sciences, professor, associate of the USSR Academy of Sciences' Institute of Geochemistry and Analytical Chemistry, Lenin Prize laureate]

[Abstract] The author reports on the status of joint Soviet-U.S. projects for spacecraft-aided research of the moon and planets of the solar system. An editorial preface to the article mentions that the author was one of a number of Soviet and American scientists who discussed plans for expanding cooperation in this field. This discussion took place in Washington in November of 1988.

Mention is made of plans for upcoming lunar probes. In line with one program, development and launching of a lunar polar satellite is contemplated during the years immediately ahead, as an international project. Information gathered in the course of subsequent lunar probes would be used in creating a permanent manned base on the moon, which could become an intermediate stage of preparations for a manned expedition to the planet Mars.

Now under way is joint Soviet-American work on selecting promising areas of Mars' surface for gathering soil samples, the author reports. The possibility of installing Soviet scientific instruments on American spacecraft, and vice versa, is being discussed in this connection. Work of the two countries in line with the Soviet projects "Phobos" and "Mars-94" and the U.S. project "Mars-Observer" is being coordinated. An accord has been reached on transmission of information from Soviet balloons and landing station on Mars to Earth via the U.S.' "Mars-Observer" satellite, which will facilitate control of future Mars rovers and transmission of meteorologic and seismic data. A joint program of balloon flights in Antarctica is planned for the purpose of calibrating "Phobos" and "Mars-Observer" equipment. Agreement has been reached on the makeup of a group of Soviet scientists who will participate, as co-researchers, in the American space projects "Mars-Observer" and Magellan", and of a group of American specialists who

are being invited to take part in the USSR's "Phobos" and "Mars-94" projects. Scientists of the two countries will take part in preparing and conducting scientific experiments, processing information and publishing data which are obtained—the first time that this practice will be introduced, according to the author.

The author relates elsewhere: "Data are being exchanged in the course of radar studies of the planet Venus. A drawn map, a topographic map, a photomosaic and a geological map of Venus are thus being compiled on the basis of radar scanning of Venus' surface from the Soviet spacecraft 'Venera-15' and 'Venera-16' and the U.S.' 'Pioneer-Venus'. Agreement has been reached on publication of a joint document listing details of the surface of Venus."

Leonov Says International Manned Flight to Mars 'Possible'

LD0502162189 Moscow TASS in English 1547 GMT 5 Feb 89

[Text] Moscow February 5 TASS—The international manned flight to Mars is possible. Most likely, it will take place early in the next millennium, a TASS correspondent was told by Soviet cosmonaut Aleksey Leonov. He noted that the hypothesis of a manned expedition to the "red planet" is being worked out in the Soviet Union and the USA. "I think that as a result of the implementation of the current international project, Phobos, it will become clear how close mankind is to making the long-held dream a reality."

Aleksey Leonov was the first man to walk in space. He also took part in the international Soviet-U.S. Soyuz-Apollo flight in 1975. At present General Leonov is deputy chief of the cosmonauts training centre near Moscow.

Speaking about the prospects for the manned expedition to Mars, General Leonov noted that foundations have been laid down already now. It is most likely that the Soviet-U.S. crew will head for the mystery planet. "As for the joint work with the astronauts, my colleagues and I have no doubts. There is a good example of that."

Evolving the subject of the future expedition, Aleksey Leonov said the reusable spacecraft "Buran", put into orbit by the Soviet space-rocket system, "Energiya", made two revolutions around the Earth. In the future this system will be able to bring 100 tons of payloads to near earth orbit or 27 tons to Mars. This can be a spacecraft manned by an international crew, the cosmonaut said.

The Soviet and U.S. programs, in particular, provide for the launch of "Earth" satellites of Mars for its comprehensive study in the early 1990s. The cosmonaut expressed the hope that Martian rock would be brought to Earth before the beginning of the next century.

Dunayev Urges International Space Cooperation

PM2202094589 Moscow PRAVDA in Russian 21 Feb 89 Second Edition p 4

[Article by A. Dunayev, chief of the USSR Main Administration for the Creation and Utilization of Space Technology: "Earth Concerns for Space: The New Political Thinking and Technical Cooperation"]

[Text] Late last year the second Soviet-French space flight—which was substantially different from previous international expeditions launched from the Baykonur cosmodrome—came to an end. The point is not just that Soviet and French envoys worked at the station for approximately one month rather than just one week, as had been the case before, and that a foreign astronaut took part in complex work outside the station for the first time. The main point is that international cooperation in the conquest of near-earth space was further developed.

During the meeting in Moscow between M.S. Gorbachev, general secretary of the CPSU Central Committee and chairman of the USSR Supreme Soviet Presidium, and French President F. Mitterrand on the day before the spacecraft launch, it was stressed that in pioneering long joint flights in near-earth space, the Soviet Union and France are making a marked contribution to organizing effective international cooperation. The hope was expressed that this flight would begin a new phase in development of relations between our countries.

But how can cooperation be better organized? This question has come to a head over the 20 years of cooperation between Soviet and foreign specialists in the sphere of creating space technology and the conquest and peaceful utilization of space.

In particular, talks have already been held at which further Soviet-French joint operations encompassing virtually all areas of space research, including manned flights, were discussed. The French side proposed making such flights once every 2 years. We agreed to discuss this question, but only on a mutually beneficial basis.

As for the financial side of the "Aragats" project, according to our estimates, the Soviet Union's expenditure has exceeded R20 million. France has compensated us for a considerable proportion of our expenditure by paying for the French apparatus delivered to the orbital complex, which Soviet cosmonauts will use in future.

This commissioning of apparatus has already become traditional. Let me recall that various Bulgarian scientific instruments; a GDR spectrometer; astrophysical instruments manufactured in the Netherlands, Britain, and the FRG; and a Czechoslovak photometer and "Kristallizator" technological unit; are still operating on

the complex. This international cooperation mutually enriches scientists from all the countries involved in the flight and helps develop national scientific schools and specializations.

Consistently developing international space cooperation, the Soviet Union has signed bilateral agreements on cooperation in the research and utilization of space for peaceful ends with France, Britain, Australia, Brazil, the United States, Austria, Italy, and India in the last 2 years alone. The USSR proposed launching foreign states' and international organizations' peaceful space apparatuses using Soviet booster rockets and has also confirmed its readiness to exchange its achievements in space with other states. Talks on this kind of cooperation are continuing. A treaty that developed a signed bilateral agreement was concluded in Vienna in November 1988 on carrying out a joint Soviet-Austrian spaceflight on a commercial basis in late 1991-early 1992.

An agreement has been signed with the U.S. firm "Payload Systems" to conduct experiments in 1989 on "Mir" to cultivate proteins to obtain new medicines.

Of course, the development of a new branch of science and technology that is so important for mankind and at the same time so costly requires the organization of international cooperation enabling the most effective use to be made of each country's achievements. Here the restrictions imposed by the Coordinating Committee for Multilateral Export Controls [COCOM] dating back to the bad times are clearly at variance with modern requirements. Thus, according to a statement by the president of the "Space Commercial Corporation" in Houston, export restrictions are impeding the implementation of a contract to launch a U.S. communications satellite using a Soviet "Proton" booster rocket. COCOM restrictions are being used [he said] to prevent us from shipping satellites and other onboard equipment onto USSR territory—even in sealed containers—to be put into orbit by Soviet launchers.

Attempts to use "strong-arm methods" to artificially retard the exchange of progressive technologies would appear particularly naive with regard to a country that can independently—without using Western technology—create such a high-tech system as the "Energiya"-"Buran" space rocket complex. Following the Soviet space shuttle's first successful flight, foreign specialists were forced to admit that their Soviet colleagues had successfully overcome the difficulties involved in creating "ideal materials, complex computer systems, and the appropriate software."

I think that abandoning the outmoded practice of prohibitions and switching to relations as equitable partners is equally beneficial to both sides. Thus, the new thinking that is winning an ever-increasing number of supporters in the world is being demonstrated in space exploration. In this situation the proposals on world cooperation in space made by M.S. Gorbachev at the UN General Assembly session resounded with particular force. There, in particular, the conversation turned to the creation of a UN emergency ecological aid center. It could hardly get by without space-based systems. Information-gathering satellite systems could be of great assistance in this matter. They should be combined with sophisticated meteorological and earth-resources technology satellite systems, which would be oriented to ecological tasks to a considerably greater extent than existing systems. In turn they can all be united into a single super-system for global information exchange and processing using earth-based and satellite systems.

Admittedly, at present a general concept for the construction of a global international system does not exist. But Soviet specialists believe that such a concept must in essence consist in organizing a purposeful improvement in space-based information-gathering and long-range forecasting systems within the framework of a single international program and pooling them into a single international ecological monitoring system.

The creation of a global monitoring system would necessitate considerable expenditure on scientific research, the elaboration of technical systems, and the development of new technologies in the sphere of space and information technology.

It should be borne in mind that some components that could be used in this system have already been created in the form of new-generation meteorological and earth resources technology space apparatus, both automated and manned. Thus, in 1991 we intend to dock a new specialized module onto the "Mir" orbital complex. In addition to the Soviet Union, five socialist countries and France are involved in creating the apparatus for it (the total weight is more than 3 tonnes). Cosmonauts in the new module will be engaged in studying the earth and the world's oceans, land, atmosphere, and the anthropogenic effect on the environment. This is effectively the prototype of an international space laboratory surveying the state of nature.

Incidentally, in the future we can also and, I think, should switch to a qualitatively new level of cooperation. Cooperation now mainly consists in giving member countries information obained from space and also in national organizations' development of scientific apparatus. In the future, specialists from various countries could begin joint activity at the stage of determining the scientific tasks for the next module and then all take part together in creating it.

This work could be carried out under the auspices of the World Space Organization as proposed at the UN rostrum. Taking into consideration all countries' interests, it could determine the paramount tasks for the utilization of space and the priority of developing specific projects on the basis of broad international cooperation. This organization would also monitor observance of a peaceful work regime in space.

It would be possible to create a system of international supervision of agreements preventing the extension of the arms race into space within the framework of the World Space Organization and utilize the technical systems the organization may have at its disposal or have leased from member states to this end. On the basis of a special agreement with the United Nations, a monitoring system could also be used to check the observance of other accords restricting and halting the arms race.

The USSR is open to cooperation with interested states, international organizations, and foreign firms in the study and utilization of space, including cooperation on a commercial basis. We proceed from the premise that business cooperation in space helps exploit the advantages of space exploration for the good of all mankind and serves as a factor for strengthening mutual understanding and mutual trust among peoples.

Finnish Cooperation in Phobos Project Discussed

LD0601181289 Moscow TASS in English 1735 GMT 6 Jan 89

[Text] Moscow January 6 TASS—The international expedition to Phobos, a Martian moon, several projects in the field of near-terrestrial plasma exploration, remote sounding of the Baltic Sea and Arctic areas with the aid of Soviet satellites are the key directions of Soviet-Finnish cooperation in space exploration. They were discussed at a three-day session of the working group on Scientific and Technical Cooperation in Space Exploration which ended in Moscow today.

Vyacheslav Balebanov, director of the Space Research Institute of the USSR Academy of Sciences, said that the inter-governmental agreement on cooperation in this area, which has been in force since January 1987, laid down the organisational foundation for joint work. Finland took part in developing several scientific instruments installed in the orbiter Phobos which should enter near-Martian orbit late this month. One of the most interesting experiments which was prepared with Finland's participation was laser ionic sounding of Phobos' surface. This will be the first experiment of its kind in planetary research.

Several more international projects involving Finland are planned to be carried out in the next few years, according to Balebanov. The launch of a satellite carrying an electromagnetic generator (the project Aktivny) is scheduled for the next year. Plasma oscillations triggered by it model plasma processes occurring in the earth's magnetosphere under the impact of the solar energy flux.

Exposing the magnetosphere to the charged particle flux is planned under the project Apeks. Finland's possible participation in the development of devices for the space observatories Spektr-Roentgen-Gamma and Spektr-UF and others is under consideration. Negotiations are conducted on Finland's involvement in the Soviet programme for Mars exploration in 1994. At issue is the development of miniature meteorological stations which will study for a long time the parameters of the Martian atmosphere.

"We are particularly interested in cooperation in remote sounding of the earth from space," said Erkki Jatilla, general director of the Finnish Meteorological Institute. "The measurement of ice cover thickness, for instance, helps make navigation easier and reduce costs. Monitoring the state of forests is also of immense importance", he said.

It is planned jointly to scan the Baltic Sea waters from the Soviet satellite Okean in February-March and in the run up to the start of the Finnish Arctic expedition to probe areas of interest to it.

Head of French Space Agency Discusses Cooperation With USSR

18660080 Moscow IZVESTIYA in Russian 24 Nov 88 p 5

[Article by B. Konovalov, science commentator]

[Abstract] The article is an interview with Jacques-Louis Lions, president of France's National Center for Space Research (CNES), a foreign member of the USSR Academy of Sciences and an eminent specialist in the field of applied mathematics. A book in this field was written by Lions in collaboration with G.I. Marchuk, president of the USSR Academy of Sciences, it is recalled.

In the interview, Lions mentions problems of cosmonautics which hold the most interest for the future, in his opinion, and he comments on results and current directions of Soviet-French cooperation in the field of space research, which has been in progress for 22 years. CNES and other French organizations contribute a total of several hundred million francs a year to Soviet-French space experiments and programs, according to Lions. Pooling of resources of the two countries has expedited the performance of very complex experiments.

Lions relates that scientists of the USSR and France have obtained interesting results in research of near-Earth space and the solar system, in particular. A number of extremely interesting joint projects are planned in the field of extra-atmospheric astronomy, including studies of the universe in gamma and x-radiation which does not reach the Earth's surface. French business circles are interested in utilizing space conditions of extremely small gravitation for industrial purposes and the advancement of biotechnology in particular. Representatives of France and the USSR Main Administration for Development and Use of Space Technology for the Economy and Scientific Research are discussing possible terrestrial uses of scientific instruments and sensing devices which were developed for space research, and

they have begun work on program for achieving compatibility of French manned spaceships of the "Hermes" series with Soviet orbiting satellites.

FTD/SNAP

Glavkosmos Official on USSR Commercial Space Services

18660091 Moscow APN: ADVANCES OF SCIENCE AND TECHNOLOGY in English No 29, 15 Oct 88 pp 1-2

[Article by Mikhail Chernyshov: "Space Research Business: The USSR's Opportunities and Proposals"]

[Text] Space research is heading for higher and higher goals. This expands the demand for services, such as placing a satellite into orbit, photographing a country's territory, and zero-gravity manufacturing of electronic components or drugs in space. Two years ago the Space Agency Glavkosmos was set up in the Soviet Union to coordinate space exploration activities, commercial included. Specific orders are also handled by V/O Soyuzkarta, Litsenzintorg and others.

"We offer transport services within the entire existing range of loads and orbits," Space Agency sector head Dmitriy Poletayev says. "Foreign customers may lease seven types of Soviet launch rockets, from light, which can place into orbit about 500 kg, to heavy boosters, such as Protons, which place over 20 tons into low-altitude and over two tons into geostationary orbits.

The Soviet Union is prepared to lease Gorizont communication satellites and channels to foreign clients. The prices will be advantageous to both partners. For example, the putting into orbit of 1 kg of payload costs 10,000-15,000 dollars and a "Gorizont," including its positioning into geostationary orbit, 35-40 million dollars. This is no more than the going rate on the world market.

Earth resources observation is a burgeoning area of space research. There are several orbital systems which can photograph Earth territory, though with different resolution: on American Landsat photos objects 30 m in size can be distinguished, an Indian IRS, 36-70 m, and on French Spot, 10 m. The highest resolution so far is shown by Soviet photo equipment—in the order of 5 m. Soviet space photos start from 500 dollars, depending on the shooting and development specifications. The buyer, a state-run organisation or a private firm, can use it without limitations—reprint, resell etc.

For the manufacture of semiconductors and other radioelectronic materials in zero-gravity conditions the Soviet Union offers the use of, for example, the "Zona" and "Splav" rocket-borne electric furnaces. The output from the ingots they make is dozens of times that which can be produced on Earth. Applications for orbital welding, in the strictly observed mode and from the customer's material, are being received. Welding can be attended, as aboard the Mir station, or unattended, as aboard Cosmos satellites.

Superpure biological and medical preparations can be produced by the "Kashtan" electrophoresis plant. In 1987 two biologically active and costly substances—thymosin and interferon—were prepared in a Cosmos satellite. Monetary settlements are not always necessary. The Soviet side is prepared to exchange capsules with orbitally-produced materials, or basic equipment. It has signed such agreements with other countries.

By the year 2000 the value of the space services market is expected to stand at two billion dollars. At one time the United States had the monopoly, placing into orbit other countries' satellites by reusable Shuttle spaceships and selling spacecraft and components. As such, the USA dictated its conditions to others. Now the situation is different: Soviet, as well as ESA and Chinese launch vehicles have appeared on the space market, and Japan and India are on the threshhold. It is now especially important for all commercial partners to build their relations on an equitable footing, without discrimination or political or other strings attached.

The Soviet Union believes space scientific and commercial cooperation should be developed with all the countries involved.

Glavkosmos Exploring Representation in U.S. in 1989

18660079 Moscow VECHERNYAYA MOSKVA in Russian 31 Dec 88 p 1

[Article by V. Dukov, deputy head of the USSR Main Administration for Development and Use of Space Technology for the Economy and Scientific Research]

[Excerpt] Results of the unique flight of the space system "Buran" are now being studied, and we are preparing for new launches of the "Buran" and "Energiya."

Unfortunately, it can now be said that we have lost one of the two spacecraft which were launched in line with the "Phobos" program. The station "Phobos-1" is not responding to interrogation from Earth. We nevertheless expect to obtain quite valuable information on Mars and its satellites.

The international ties of the Main Administration for Development and Use of Space Technology for the Economy and Scientific Research (Glavkosmos) are expanding. A mission of a cosmonaut from Austria is planned for 1989, and we are preparing for a joint mission of a Soviet-West German crew.

In 1989, a Soviet-American enterprise may come into being which will represent Glavkosmos in the United States and expedite exchange of space technologies.

FTD/SNAP

Successful Mars Probe, 'Buran' Plans Viewed

LD0302231989 Moscow in English to Great Britain and Ireland 2000 GMT 3 Feb 89

[Text] Last Sunday a Soviet spacecraft, after a voyage of over half a year, went into orbit around Mars. This and other developments in the Soviet space programme are the subjects our science correspondent Boris Belitsky discusses in "Vantage Point" today:

[Belitskiy] Twelve other countries and the European Space Agency, as well as the Soviet Union, contributed instruments to this spacecraft, which on Sunday afternoon fired its retro rocket for exactly 201 seconds to slow its flight and slip into orbit around Mars. Its flight is being tracked by giant radio telescopes not only in the USSR but also in the United States, Spain, and Australia. But it was only 10 minutes after the breaking maneuver that an audible sigh of relief went up at the mission control center at Kaliningrad near Moscow. This was because that's the time it takes for a radio signal to cover the distance from Mars to Earth, or from the Earth to Mars for that matter. Imagine turning the steering wheel of your car and having to drive on for 10 minutes before the car begins making the turn. The sigh of relief at mission control was on this occasion particularly deep because this Soviet interplanetary probe, called Phobos 2, has no back-up. The insertion into orbit just had to be successful otherwise the project was simply over. This was because the sister craft Phobos I had last September been put out of action by the omission of a single letter in a command dispatched to it — an omission estimated to have cost R300 million according to the now very cost-conscious leadership of the Soviet space program.

Soviet deep space ballistics experts have just worked out the exact parameters of the Phobos 2 craft's orbit around Mars, and following this the craft's sophisticated instruments have begun a detailed study of the Martian surface including its chemical and mineralogical composition, the planet's atmosphere, ionosphere, and magnetosphere. This study of Mars is expected to continue for 2 months instead of the earlier planned 3. After that, if all goes well, the craft will be transfered into an orbit around the Martian satellite Phobos for a fascinating study of that Martian moon at close range. And not only at close range—the project includes the first ever landing on a minor body of the solar system. Two landers are to descend on Phobos, one of them a leap-frogger which is to bound across the satellite's surface in 20-meter leaps: another fascinating first in space exploration.

Meanwhile, scientists and engineers associated with the Soviet space shuttle Buran are busy analyzing the results of its extremely impressive maiden flight last November to decide whether its next flight is to be unmanned as planned earlier or manned, considering the success of the maiden flight. Seven cosmonauts have now been selected as the contingent for flights aboard Soviet reusable spacecraft of the shuttle type, with Igor Volk as the obvious number one candidate thanks to his space flight experience. If it's decided to have the next flight manned, Buran will be flown by a two-man crew, with 51 year-old Volk almost certainly its commander. But Volk himself takes the view another unmanned flight may be needed to put Buran through its paces in the type of flight that its crew plan to undertake.

Party Secretary Baklanov Views Shuttle Technology, Expenses

LD0802022889 Moscow Television Service in Russian 1800 GMT 7 Feb 89

[From the "Vremya" newscast]

[Text] Today Comrade Baklanov visited the scientific production association Energiya near Moscow. In conversations with economic and party leaders and specialists directly involved in developing, building, and conducting tests on the Energiya-Buran space shuttle transport system, the state of the art was examined. The discussions concerned the creation of new space technology in the interests of the national economy, fundamental research, and international cooperation in space research.

The implementation of space projects requires a good deal of expenditure. For this reason the CPSU Central Committee secretary paid particular attention to the need to step up the work of transferring scientific and technical achievements and developments implemented in the Energiya-Buran system to other sectors of the national economy. The issues of increasing the production of consumer goods at the association and the development and manufacture of engineering equipment for the processing sectors of the agro-industrial complex were examined.

Notes Economics of Research, Use

PM1002111189 Moscow PRAVDA in Russian 8 Feb 89 Second Edition p 2

[TASS report: "Space Geared to the Economy"]

[Text] Space exploration is more and more convincingly becoming an inalienable element of the economy. The rapid development of space technology has been a mighty incentive for improving machine building, electronics, power engineering, and other industrial sectors. Man's life in the modern world is already inconceivable without space communications, navigation, meteorology, the study of earth's natural resources from space, and medical and technological experiments in near-earth orbits. Scientific and technical potential is being sharply accumulated in the sphere of the study and utilization of space. The Energiya Science and Production Association near Moscow, which O.D. Baklanov, secretary of the CPSU Central Committee, visited on 7 February, plays a leading role in the creation and utilization of space technology.

In conversations with economic and party leaders and specialists who have taken a direct part in the development, manufacture, and testing of the Energiya-Buran space shuttle transport system, the state of affairs with regard to the creation of new space technology in the interests of the economy, fundamental research, and international cooperation in space was examined.

The implementation of space projects necessitates considerable expenditure, and that is why the CPSU Central Committee secretary drew particular attention to the need to speed up work to apply to other economic sectors the scientific and technical achievements and developments that have been brought to fruition, for instance, in the Energiya-Buran system. Even today this will be producing an economic effect that fully compensates for the expenditure on space research.

Questions of increasing the association's production of consumer goods and developing and producing manufacturing equipment for agro-industrial complex processing sectors were also discussed. The CPSU Central Committee secretary was briefed on the development of the social sphere at the enterprise and within the city; he inquired about progress in preparing for elections to the USSR Supreme Soviet.

O.D. Baklanov was accompanied by V.Kh. Doguzhiyev, USSR minister of general machine building; K.V. Frolov, vice president of the USSR Academy of Sciences; and other party and economic leaders.

Space Program Expenses, Secrecy Questioned

PM3003095989 Moscow IZVESTIYA in Russian 22 Mar 89 Morning Edition p 2

[S. Leskov article: "Space and the Kopeck. Cosmonautics Remains a Closed Bastion to Free Discussion"]

[Text] The unprecedented point about the need to reduce spending on space programs has appeared in the election programs of many people's deputy candidates.

This thesis naturally displeases many specialists working in cosmonautics and makes them annoyed with its authors. But, to get away from professional ambition, the very fact that topics once considered closed are now being publicly addressed can only be welcomed.

For decades cosmonautics was considered almost a national economic sacred cow the scale of whose sustenance it was sinful and unpatriotic to question. Responsibility for the common cause and a sense of involvement in what is happening in the motherland are now being revived everywhere. It is also true that the following fact has been noted. Certain candidate deputies promise their voters almost a land flowing with milk and honey. And the promises are not always backed up by precise figures and specific knowledge. People can only complain that the cost of "Buran," "Phobos," or a crew's year-long stay on board an orbital station is still a deep secret. You cannot be satisfied with the vague replies heard at news conferences about "our spending being comparable with the Americans'." If it really is comparable, why play at secrecy, why not name the sum directly? But when it is not named, you inevitably imagine astronomic appropriations which, when you look at empty store counters, you cannot help wanting to cut.

So we simply do not know whether it will be possible to save a lot or a little in cosmonautics. But it is not even a matter of this. Cosmonautics means advanced technology, and in no other sphere are scientific achievements introduced so quickly into practice. This is the reason why more and more states which you might think cannot yet dream of space travel are turning their gaze toward cosmonautics—Brazil, Malaysia, Australia. Cosmonautics is the most profitable bank in which to deposit the latest scientific and technical achievements. And with correct organization it yields unprecedented interest.

For a very long time the USSR's space departments showed little concern to "come down to earth." A change for the better can now be observed in this respect. Unfortunately, the handful of positive examples has not yet become a system.

Concern at the rational running of the space sector is fine. But to achieve this goal it is hardly correct to speak of a mechanical reduction in spending. We have enough money, and there will be more—there will be no increase in sausages. We should think about orienting the achievements of a technically advanced sector toward the needs of the national economy. And not only space departments must show an interest in this. The clients themselves must show no less interest. But so far an extremely narrow circle of people knows about the potential of cosmonautics—we do not propagandize its potential in the best way.

Here is a final comparison, by no means in our favor. The U.S. craft "Discovery" only spent 1 week in orbit, but on one of the days earth dwellers were provided with a unique opportunity to listen in to the astronauts' conversations with the National Flight Control Service over the ordinary telephone for a very moderate charge. And not only U.S. citizens were able to do this but also inhabitants of any other country, including the USSR. Our crews are serving continuously on board the "Mir" orbital complex, and we would seem to have immeasurably greater opportunities, but we have nothing to boast of in this respect. Nothing fascinating has happened on board for several months. Many people gain the false impression that the "Donbasses" are on board the station only to "keep it going," pending upcoming expeditions.

The USSR Main Administration for the Creation and Utilization of Space Technology has repeatedly declared that it has adopted a policy of concluding commercial

contracts with foreign partners to use Soviet space equipment. However, things are being run in such a way that the time has come to convince our own fellow citizens of the prudence of spending on cosmonautics.

'Mars-94' Program Discussed at Technical Conference

LD1802213888 Moscow TASS in English 2032 GMT 17 Feb 89

[Text] Moscow Feburary 17 TASS—In a lapse of almost 15 years after American Viking probes landed on the surface of Mars, this planet is becoming once again a priority target of space programs of the USSR, the United States, and other countries.

At an international scientific conference, which ended on Friday at the Soviet Academy of Sciences' Institute of Space Research, scientists from over a dozen countries discussed technical specificities of the Mars-94 project and the range of scientific experiments.

Under this project it is planned to launch one or two space probes in the USSR in the autumn of 1994, which should reach a near-Martian orbit in September 1995. A balloon and several miniature research craft will be dropped on the planet's surface. The orbiters are supposed to be launched by Proton rocket-boosters. According to tentative estimates, the automatic craft's aggregate mass will amount to 6,500 kilograms, of which scientific instruments will account for 200 kilograms.

"A return to the exploration of Mars takes place on a new technical basis", Albert Galeyev, a corresponding member of the USSR Academy of Sciences and Space Research Institute's director, told TASS.

"None of the eleven Soviet and American space probes which explored the planet in the 60s and in the 70s could provide a definite answer to the question whether life existed on Mars, was it preserved and if not then why was it extinct. More sophisticated telesystems, spectrometers, radars, and also a balloon and probe-penetrators will allow specialists to come closer to unraveling this mystery. An expedition to return Martian surface samples will evidently help scientists to come to grips with this problem. This is a very complicated and costly operation. Therefore, it should be preceded by a detailed exploration of possible areas for landing".

Galeyev stressed that the Soviet project does not repeat the American "Mars-Observer" which envisages the launch of a spacecraft to a near-Martian orbit in 1992, but has independent tasks to accomplish. For instance, the Mars-94 project stipulates a detailed exploration of the planet's atmosphere with the aid of spectrum equipment and the study of its magnetosphere.

The balloon experiment will be the first of its kind carried out simultaneously with the work of several research craft on the planet's surface. By the way, "Mars-Observer" plans to carry a French device to collect information from the Mars-94 balloon. This will enable specialists significantly to increase the amount of information transmitted to the earth.

"Mars-94 will allow people dramatically to extend knowledge about the planet of the solar system, which has more in common with the Earth than any other outer planet", says Tobias Owen, professor at New York University who attended the conference. "The promising part of the program is radar probing of subsurface layers at a depth of several kilometres. Possibly, scientists will succeed in discovering permafrost".

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